November, 1979
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Philip Morrison on U.S. Defense
Disposing of Hazardous Waste
Renewable Energy for the World's Poor
Storing Power in Flywheels

Technology Review

Edited at the Massachusetts Institute of Technology

Innovation in the Construction Industry

technology
review
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Edited at the Massachusetts Institute of Technology
Volume 82, Number 2
November, 1979

Technology Review

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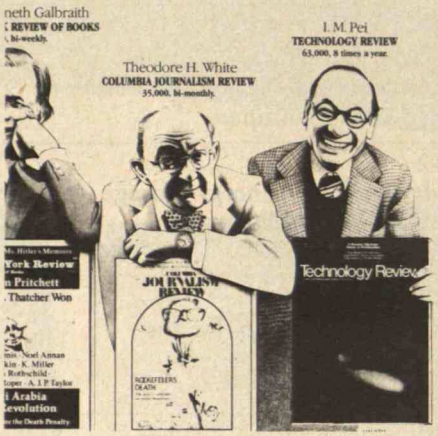

Faces Behind Magazines

Daniel Moynihan, Henry Kissinger, John Kenneth Galbraith, and I. M. Pei pushing magazines?

You saw it happening in this magazine last month (*pages 78-79*), and it also happened in the *New York Times*, in the advertising trade press, and on some billboards in key New York City locations. (*Time* noticed, too, and wondered if the advocates had second thoughts; Mr. Galbraith, at least, did not.)

The campaign — a low-budget one to which eight magazines involved made modest contributions — is another evidence of the entrepreneurship of Rob Sennott, founder of the Leadership Network. Through the Network he represents the eight magazines for advertising sales, offering discounts to advertisers who take space in several or all of the publications.

The eight are happily characterized by the *New York Times* as "thought-packed": *Atlas World Press Review*, *Columbia Journalism Review*, *Commentary*, *Foreign Affairs*, *National Review*, *New Republic*, the *New York Review of Books*, and *Technology Review*. With these eight magazines in his pocket Mr. Sennott can offer advertisers 620,000 readers (almost no overlap) on a single order.

Our man is I. M. Pei, who's read *Technology Review* almost ever since he was graduated from M.I.T. in 1940. He was our first choice to represent the *Review* in this distinguished company of readers, and — like all the other magazines' first choices — he said yes. We're grateful indeed.

And grateful, too, to Rob Sennott and his colleagues at the Leadership Network; *Technology Review* advertising has grown apace since he invited us to join the Network in 1977, and we commend our advertisers to all our readers. — *J.M.*

Rigging for Speed

In "Sail Power for the World's Cargo Ships" (*March/April*) Mr. Lloyd Bergeson gave insufficient attention to the change in the direction of the apparent wind which a large efficient sailboat can effect. A 200-foot cargo vessel is over four times as long as a typical cruising sailboat, and should in theory sail over twice as fast. Mr. Bergeson points out a 12-knot beam wind on such a large sailboat should increase to effectively 20 miles per hour as a result of the boat's motion. However, he fails to mention that this "beam" wind will now be only 37° off from dead ahead.

It takes a very efficient sailing rig to extract useful forward thrust from wind 37° off the bow. Furthermore, when this 200-foot boat is trying to beat to windward the angle of the wind becomes even more difficult to harness effectively. The multi-sail boomless rig suggested by the author, though it may be more efficient than square sails, is nevertheless hopelessly inadequate for beating to windward at reasonably high speeds. At the very minimum, an efficient sloop rig would have to be used, but more likely it would be necessary to have a high aspect ratio, high efficiency "una" rig used on large racing Class C catamarans.

Actually this problem of the change of direction in apparent wind makes it almost impossible for a really large sailboat to sail to windward at anywhere near its speed potential in a moderate 12-mile breeze, and partly for this reason large commercial sailboats are designed primarily for winds blowing faster than the velocity of the ship.

Therefore, I agree with Mr. Bergeson that auxiliary power would be very desirable for a modern sailing ship. It should be used at any time that the wind drops below Force 4, which is most of the time in many areas of the ocean. As a result the fuel savings should be much lower than Mr. Bergeson projects for his sailing ships.

The auxiliary power should probably not be used when the ship is sailing to windward as the author suggests. A sailboat that is on the wind cannot efficiently use auxiliary power because the increased speed will only bring the apparent wind closer to dead ahead, and therefore the boat must bear off in order to bring the apparent wind's angle back to where the sails can efficiently use this wind. This means that although the boat using auxiliary power can move faster, its course makes a greater angle from the true wind, and the boat does not go to *windward*

(Continued on p. 4)

ALUMNI FLIGHTS ABROAD
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A newly-expanded program of travel now offers an even wider choice of journeys to distant and fascinating areas of the world, including for 1980 the islands of the Galapagos, the Nazca Lines and the desert of Peru, the Amazon, the unusual lands of southern India, an expanded program of discovery to the ancient cities of Greece, Asia Minor and the Aegean, new and more extensive itineraries in ancient Egypt and in the Far East and in India and the Himalayas, as well as the ruins of Tiahuanaco in Bolivia and the Stone Age world of New Guinea, the lands of New Zealand and Australia, the islands of the Seychelles, and game-viewing in the wilds of Kenya and Tanzania.

The travel program is a special one for alumni and alumnae of Harvard, Yale, Princeton, M.I.T., Cornell, Univ. of Virginia, and certain other distinguished universities and for members of their families. Now in its 16th year, it is designed for educated and intelligent travelers and planned for persons who might normally prefer to travel independently, visiting distant lands and regions where it is advantageous to travel as a group.

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SOUTH AMERICA and THE GALAPAGOS: A choice of itineraries of from 12 to 29 days, including a cruise among the islands of the Galapagos, the jungle of the Amazon, the Nazca Lines and the desert of southern Peru, the ancient civilizations of the Andes from Machu Picchu to Tiahuanaco near Lake Titicaca, the great colonial cities of the conquistadores, the futuristic city of Brasilia, Iguassu Falls, the snow-capped peaks of the Andes and other sights of unusual interest.

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THE SOUTH PACIFIC and NEW GUINEA: A primitive and beautiful land unfolds in the 22-day EXPEDITION TO NEW GUINEA, a rare glimpse into a vanishing world of Stone Age tribes and customs. Includes the famous Highlands of New Guinea, with Sing Sings and tribal cultures and customs, and an exploration of the remote tribal villages of the Sepik and Karawari Rivers and the vast Sepik Plain, as well as the North Coast at Madang and Wewak and the beautiful volcanic island of New Britain with the Baining Fire Dancers. To the south, the island continent of Australia and the islands of New Zealand are covered by the SOUTH PACIFIC, 28 days, unfolding a world of Maori villages, boiling geysers, fiords and snow-capped mountains, ski plane flights over glacier snows, jet boat rides, sheep ranches, penguins, the Australian "outback," historic convict settlements from the days of Charles Dickens, and the Great Barrier Reef. Optional visits can also be made to other islands of the southern Pacific, such as Fiji and Tahiti.

CENTRAL ASIA and THE HIMALAYAS: An expanded program of three itineraries, from 24 to 29 days, explores north and central India and the romantic world of the Moghul Empire, the interesting and surprising world of south India, the remote mountain kingdom of Nepal, and the untamed Northwest Frontier at Peshawar and the Punjab in Pakistan. Includes the Khyber Pass, towering Moghul forts, intricately sculptured temples, lavish palaces, historic gardens, the teeming banks of the Ganges, holy cities and picturesque villages, and the splendor of the Taj Mahal, as well as tropical lagoons and canals, ancient Portuguese churches, the snow-capped peaks of the Himalayas along the roof of the world, and hotels which once were palaces of maharajas.

THE FAR EAST: Itineraries which offer a penetrating insight into the lands and islands of the East. THE ORIENT, 30 days, surveys the treasures of ancient and modern Japan, with Kyoto, Nara, Ise-Shima, Kamakura, Nikko, the Fuji-Hakone National Park, and Tokyo. Also included are the important cities of Southeast Asia, from Singapore and Hong Kong to the temples of Bangkok and the island of Bali. A different and unusual perspective is offered in BEYOND THE JAVA SEA, 34 days, a journey through the tropics of the Far East from Manila and the island fortress of Corregidor to headhunter villages in the jungle of Borneo, the ancient civilizations of Ceylon, Batak tribal villages in Sumatra, the tropical island of Penang, and ancient temples in Java and Bali.

Prices range from $2,350 to $3,900 from U.S. points of departure. Air travel is on regularly scheduled flights of major airlines, utilizing reduced fares which save up to $600.00 and more over normal fares. Fully descriptive brochures are available, giving itineraries in detail and listing departure dates, hotels, individual tour rates and other information. For full details contact:

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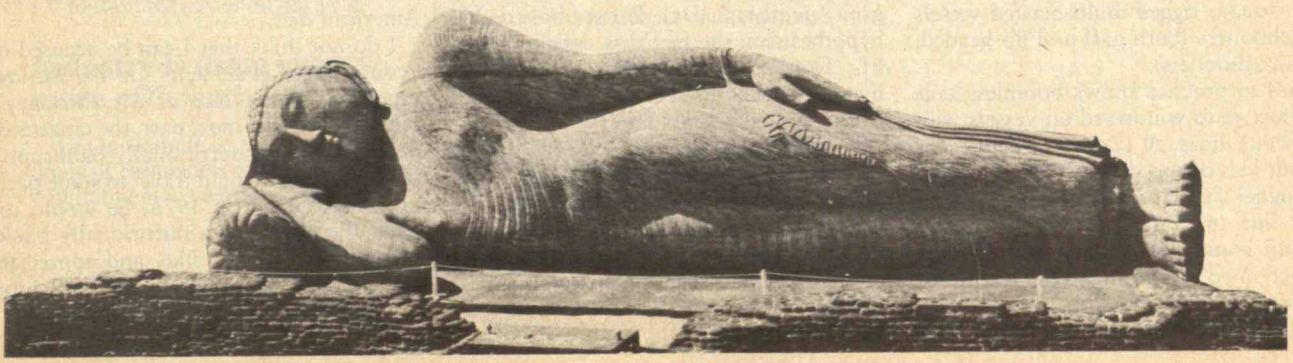

Letters

(Continued from p. 2)

that much faster than when no auxiliary power is used.

I don't think that catamarans will be good for sailing *cargo* ships as they are slowed terribly by added weight. However, for very light cargo such as *passenger* transport, or cruise ships, sailing catamarans might be very practical. Though their light weight would make for uncomfortably quick response to the ocean swells, I could imagine that for touring the Aegean Islands, a large sailing catamaran could give the clientele a new dimension of excitement. During light winds the catamaran would move very slowly and permit sunbathing unsullied by the noise, smell, and speed-induced wind of a motor driven ship. When the wind becomes too strong for comfortable sunbathing on deck, the passengers of a 220-foot sailing catamaran would be treated to a display of speed that will yield unparalled cocktail conversation when they return home.

John M. Bradley
Manchester, Mass.

Mr. Bergeson responds:

Mr. Bradley discusses some of the problems in the massive trade-off matrix which constitutes the process of ship design. These matters will be significant in the second phase of our development program. At this time, we do not intend to specify a particular rig as being best; but we can postulate for performance and economic analysis those which can significantly improve reaching and close winded performance over past rigs — notably over the square rig and its modern versions and the gaff-rigged schooner of 1902.

A large scale "una" rig would be fascinating to try out on a commercial ship prototype. A sloop rig, of course, is more efficient than a schooner rig; and a two-masted schooner more efficient than a three-master, etc. However, mast heights are limited by bridge clearances in major ports and sizes of individual sails will be limited by strength of materials and practicalities of sail handling and safety. This leads inevitably to a multi-masted vessel with its lesser efficiency to windward than a sloop. But we are really concerned with an analysis of *relative* efficiencies as between square rigged multi-masted vessels and schooners (both gaff and jib-headed, staysail schooners).

Proof in practice shows boomless sails are effective to windward on vessels with long water lines. A 12-meter yacht tacks without loss of speed in 62-65° according to designer Ted Hood. *Aria* with her long water line (67.5 feet) and loose footed mainsail consistently tacks, without loss of speed in 63° according to the records of her owner George Kress. A 220-, or 400-, or 600-foot schooner might reasonably be expected to do almost as well if their helmsmen are trained to sail them so they don't stall out.

Multi-masted square rigged vessels and fore and aft rigged vessels suffer severe losses of efficiency with the wind dead aft. Thus the square riggers were always tacked downwind in order to optimize speed and the modern ships will also have to be so managed. Many of us also tack our *sloops* downwind to advantage!

With respect to the use of auxiliary power to enhance performance to windward, I invite Mr. Bradley to sail with me on my yacht *Cockatoo II* (31 foot length at water line and 20,000 lbs.) and observe what less than six shaft horsepower used with sails will do to improve her performance to windward in light airs!

Mr. Bradley suggests catamarans will only be successful in the leisure trade where cargo is of low density, i.e. human passengers and their accoutrements. This is a possibility. There are however, other low density commercial cargoes that are worthy of analysis.

Diet and Disease

"The Megamyth of Megavitamins" by David M. Ross uses scare tactics, innuendoes, and editorialized statements.

The statement that "ingesting only five times the R.D.A. (for Vitamin A) over a six month period can incur Vitamin A poisoning (20,000 I.U./day), does not accord with the Merck Manual which states that chronic poisoning occurs when Vitamin A is taken in doses of over 100,000 I.U./day for many months. The Merck Manual also states: "Excessive ingestion of carotene (carrot juice) does not cause hyper-vitaminosis A."

With the same disregard for published facts, we are told those excessive amounts of Vitamin E are "any amounts above 10 milligrams per day." The R.D.A. gives 30 milligrams per day. It is also totally incorrect to say that Vitamin E still remains enigmatic. Dr. Wolf and Mr. Ross might review "Vitamin E and Its Role in Cellular Metabolism" (New York Academy of Science) and the many articles by Dr. Wilfrid E. Shute, M.D.

In contrast to Dr. Wolf's negativism, Dr. Linus Pauling and Dr. Roger J. Williams have given our society a great insight as to how we can stay healthy. Also, my long-time associate, Dr. J. Rinse, has helped thousands to control/cure angina pectoris. Dr. Rinse based his hypothesis on the fact that deficiencies in his food could be the cause. His hypothesis was correct and he is hale and hearty some 21 years later.

For the most part, the citizens of our country are nutritionally bankrupt. It behooves persons like Dr. Wolf and Mr. Ross to help their fellow man; it behooves the editors of the *Technology Review* to present true and scientific material.

Richard S. Mooney
Bernardsville, N.J.

Dr. Wolf responds:

I am sorry Mr. Mooney feels belligerent about my statements on Megavitamin Therapy. It was not my intention to use "scare tactics" — if the reader of the article was scared, it was not meant as a tactic to elicit that response.

To comment on some of Mr. Mooney's statements: the R.D.A. for vitamin A for an adult is 5,000 I.U./day. Hence five times this is 25,000 I.U./day, an amount stated to be risky (*see* Nutrition Reviews, *Special Supplement, July 1974, vol. 31, p. 41*). Mr. Mooney should read about three case histories of vitamin A intoxication and the dire consequences, reported by two physicians, Drs. Smith and Goodman (New England J. Med., *294: 805, 1976*). One describes a very sick college student who had taken 50,000 I.U./day for two years, later 400,000 I.U./day plus six carrots for an undetermined time.

With regard to carrot juice, B-carotene is absorbed and converted to vitamin A ester to an extent 60 per cent greater than the dose by man (*Goodman et al.*, J. Lipid Res., *6: 390, 1965*). Therefore, when taken in addition to vitamin A pills, it would most certainly contribute to vitamin A intoxication.

I apologize for the statement that execessive amounts of vitamin E are those greater than 10 milligrams per day. This should have been 30 milligrams per day (the very generous R.D.A.). The error slipped in somewhere between my lecture and its publication.

Despite the many articles on vitamin E, we still know of no clearly discernible function for it in animals, let alone in man. Animal experimentation would suggest an anti-oxidant effect, though this still remains to be finally proved. I suggest that Mr. Mooney read the article on vitamim E in the same issue of *Nutrition Reviews*, p. 37, which states that many studies of the effect of this vitamin on heart disease have given no evidence of a beneficial action. Nonetheless, since we are really ignorant of how vitamin E deficiency causes muscular dystrophy in animals (though not in man), possibly some effect on muscular function may emerge from future research. I am glad that Dr. Rinse is still hale and hearty 21 years after taking vitamin E. I would suspect that his health is good in part because his diet is not deficient in any of the vitamins, unless he eats a very un-American diet.

I do not think that I can be accused of "editorialized statements" in my lecture, especially in the face of Mr. Mooney's sentence "for the most part, the citizens of our country are nutritionally bankrupt." If Mr. Mooney would travel to some parts of Asia, as I did in 1976, he would see what the effects of a nutritionally bankrupt diet really look like, and appreciate the on-the-whole very excellent food supply we have available here.

How Has Industry Responded To Rising Energy Costs?

Conservation controls energy costs.

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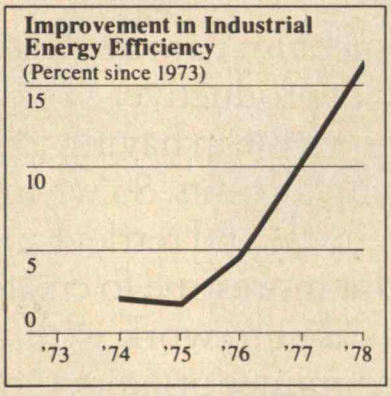
Energy conservation serves Union Carbide's self-interest because it helps keep our products competitive by offsetting rising energy costs. Obviously, our energy conservation program also serves the national interest—saving the equivalent of 1.3 million barrels of oil per year.

Industry is using energy more efficiently.

Union Carbide is only one of hundreds of companies with an ongoing commitment to energy conservation. As the chart below indicates, the energy efficiency of American industry has improved 16 percent since 1973.



As a result of conservation, industry used less energy in 1978 than in 1973, even though production was up about 12 percent. And industry's share of total U.S. energy consumption has dropped from 40 percent to 36 percent over this interval.

Decontrolled energy prices would stimulate additional conservation.

In the public debate on the nation's energy future, more and more attention seems to focus on conservation. At Union Carbide, we believe conservation must play a major role in America's efforts to achieve energy security. Deliberate phasing out of the price controls on energy would increase the incentives for all sectors of the economy to conserve—and stimulate the development of additional energy supplies as well.

Everybody wants to see America use energy more efficiently. And while higher prices are unpopular—with consumers and with Congress—it is an unalterable fact that they are an important step in getting this job done.

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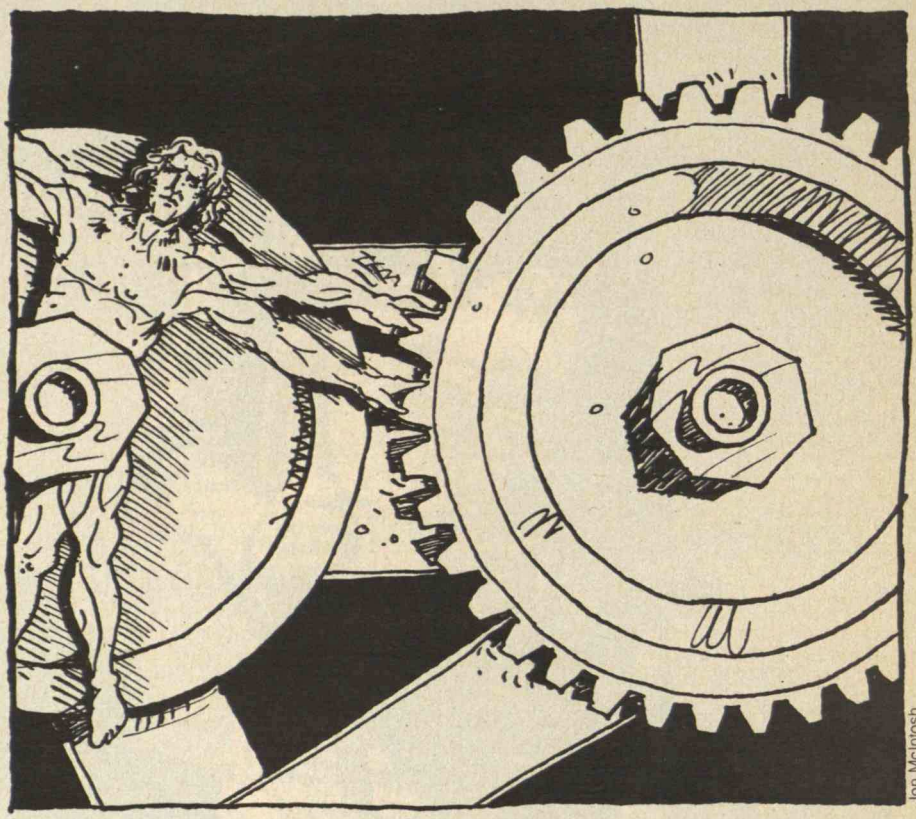
A Not-So-Simple Little System

Kenneth E. Boulding is Director of the Institute of Behavioral Science and Professor Emeritus of Economics at the University of Colorado at Boulder. He is a regular contributor to Technology Review.



Jon McIntosh

The General Systems movement, and I think one can dignify it by this name, has certainly not set the world on fire. Although it has been necessary and very much worth the effort, it still survives precariously in the academic community as an eccentricity, mainly taught and practiced by individuals who are mostly paid to do other things.

At the moment of writing I am attending the rather stormy Silver Anniversary International Meeting of the Society for General Systems Research in London. As I was one of the four original founding fathers and the first president of this Society, the occasion is both an invitation to nostalgia (one of the greatest illicit pleasures of later life) and to re-examination, either for reaffirmation or for repentance. I must confess to being a little short on repentance, even in general, and certainly in this special system. My role in the General Systems enterprise has been perhaps more that of a proposer and exhorter than a doer, though I have taught a course in General Systems, suitably disguised in the college catalogue, out of which emerged my book on ecodynamics. Of all this I repent very little.

I doubt if there are more than ten (at most 20) universities around the world where General Systems is a recognized program, either of teaching or of research, though the number is growing. I know of nobody who really holds a job as professor of General Systems, and I know of no endowed chair in this field.

Doors Between Disciplines

In the original "manifesto" of the Society for the Advancement of General Systems, which later changed its name to the Society for General Systems Research, we defined a general system as any theoretical system which was of interest to more than one discipline. (I quote from memory and am a long way from the original records, so the reader is warned that memories are fallible.) Thus the General Systems enterprise was originally conceived in modest terms. We did not propose the creation of a General Theory of Practically Everything, and we certainly did not want to destroy that discipline which is the main virtue of, and excuse for, the disciplines. But we did want to put doors, or at least windows, in the walls which prevented the disciplines from communicating with each other, in the hope that they could learn from one another.

Underneath this modest enterprise, however, there is a suspicion of an outrageously immodest one. This presumption rests in the first place on the belief, beyond all quirky philosophical doubts, that there is a real world, which includes humans and everything inside them as well as everything outside them. In the second place, it rests on the belief that the human mind is a remarkable structure capable of forming images or mappings of the real world. These images exhibit degrees of "truth," measured hypothetically by the extent to which there is a one-to-one correspondence between the image ("map") and the part of the real world to which it corresponds. We can never be sure what degree of truth our images possess, but we do have a capacity for correcting error in our images by the process of feedback. This means that there is a bias in the change of images through time towards truth, as erroneous images are more likely to be changed than true ones. The outrageous and immodest leap of which General Systems is suspect is the belief that the real world, stretching from the tiniest teacup to the whole universe spread out through 20 billion years of time and an equivalent amount of space, follows one pattern. And even more is the assumption that the feedback process of eliminating error leads toward mental images that increasingly correspond to this pattern. We cannot be content with parts of the pattern; we seem to have inexorable drive to want to understand the whole.

Equal Time for Humility

Now, of course, it is time for humility to break in. The real world must be more complex than our own brains, which are only part of it and have been produced by it. Human images, therefore, can never be as complex as the real world which they aim to represent. There must be limits to human knowledge, though we still seem to be a very long way from them. There are, furthermore, pathologies of learning — wishful thinking, biological imprinting, plausible illusions, and so on — which may shrink the knowledge limits serious-

(Continued on p. 84)

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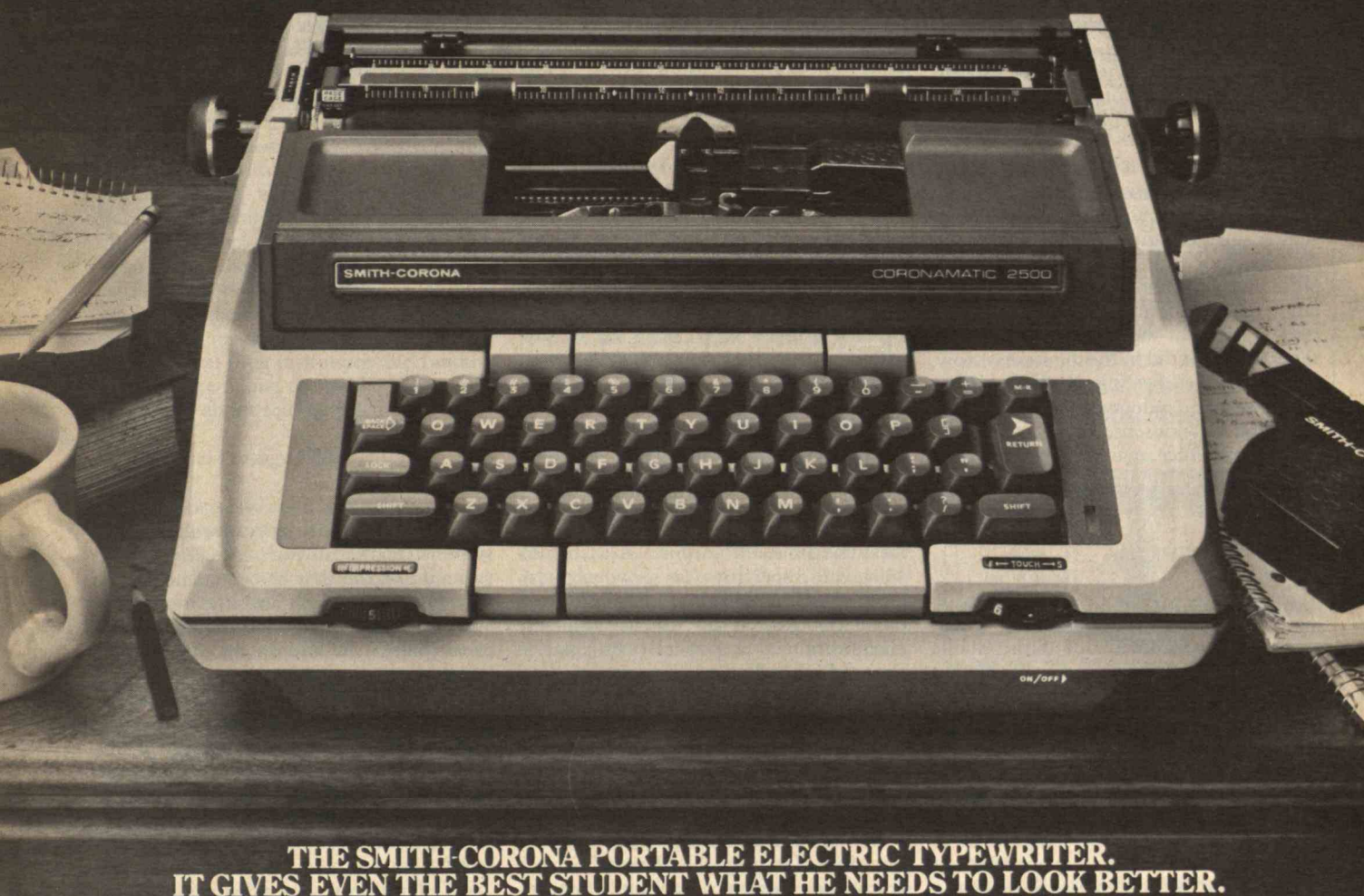

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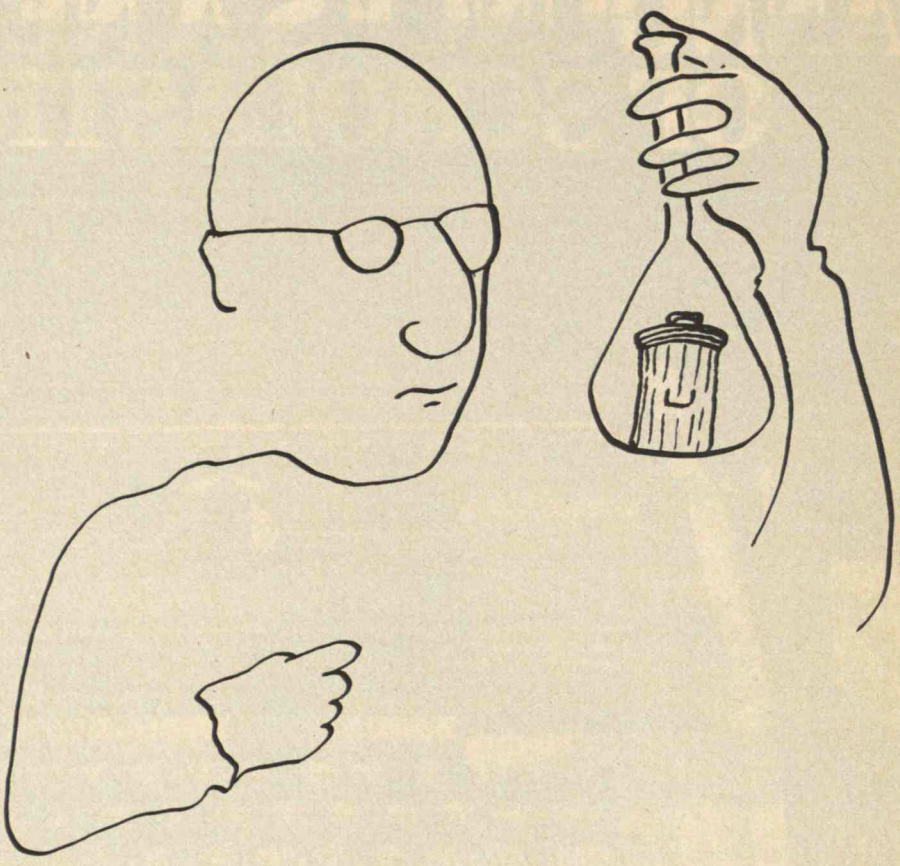
Garbage Under Glass: What are Scientists Dishing Out?

Robert C. Cowen, Science Editor of the Christian Science Monitor, *is former President of the National Association of Science Writers and is a regular contributor to the* Review. *He holds S.B. and S.M. degrees in meteorology from M.I.T.*



Michael Crawford

For science writers, it was a familiar scene. Newspapermen describing stories about studies of 65-million-year-old rocks by Walter Alvarez and colleagues from the University of California at Berkeley had picked up some non-too-persuasive speculation that an anomalous concentration of iridium might be the signature of a nearby supernova that did in the dinosaurs. Now, at a scientific meeting, a distinguished geologist was denouncing "irresponsible" reporting of "nonsense" that ought to be suppressed. Once again, the press took it on the chin for reporting what scientists had said.

Well-Bred Garbage

It's an old story, but one worth a second look because many scientists and engineers are concerned about the public image of their work. The press has always had a lot to answer for. Along with incisive and responsible reporting, there has always been a spectrum of errors of omission and commission, bias, distortion, and hype. But in their eagerness to improve their image, scientists and/or their institutions are becoming part of the problem in a new and insidious way. I'm not referring to scientist-activists who use the press as a sounding board to promote solar energy, denounce nuclear power, or raise an alarm about their latest fear for the environment. Their often one-sided advocacy does little to help the cause of balanced reportage, but that is another issue. I'm talking here about naive publicizing that results in press reports which scientists reject as garbage without realizing that they, or their institutions, are responsible for the input which leads to that garbage. Here are a few examples:

Last spring, there was a spate of stories about the "mystery object in the Milky Way that seems to be coming and going at the same time." The object is a star (SS 433) whose spectrum has shown a puzzling display of red-shifts, blue-shifts, and rapid changes. When asked about the phenomenon at a public symposium in June, M.I.T.'s Philip Morrison dismissed the reports as foolish and misleading "newspaper talk." Foolish they may be, but I took the above quote from an official announcement of the University of California at Los Angles, as did the reporters who spread the story last spring.

Another astronomical marvel was disclosed in March by the National Science Foundation which announced that astronomers under N.S.F. contract had identified "the most massive spiral galaxy yet known — billions of stars and enormous clouds of dust and gas swirling in a disc containing probably ten times more matter than the Milky Way . . ." It was the galaxy NGC 1961, a well-known cosmic denizen listed in the *New General Catalog* years ago. I was visiting galactic astronomer Alan Sandage at the Hale Observatories at the time and asked him what he thought of the announcement. "Gee," he replied, "I wonder what they know that I don't."

Both of these stories referred to important astronomical work. SS 433 is indeed a major puzzle that has stimulated much good observational and theoretical research. And the studies of NGC 1961 have given new insight into the history and dynamics of that galaxy, as well as a better estimate of its mass. But the attention of the press was diverted by needless hype in official announcements — in the one case, raising a foolish image in the journalist's mind, and in the other case thoughtlessly implying that a spectacular new astronomical object had been discovered.

While annoying, such distortions are no immediate threat to the public good. The following little horror story from the University of Illinois at Urbana-Champaign is less benign. It plays upon the widespread public concern about trends in the weather. During the height of the alarm over oil pollution in the Gulf of Mexico in August, the university issued a press release which began: "If the huge oil slick spreading out from a broken Mexican offshore oil well continues to expand unchecked, it could produce a serious drought in the Midwest." It went on to quote a retired engineer of the Illinois

State Water Survey, which is located at the university, explaining his theory that the oil would cut off moisture from the Gulf and thus "could create a continuous drought." This is pure nonsense, as survey meteorologists would have told the university News Bureau had the Bureau bothered to check. But, eager to get the university's name in the papers, the information officer rushed out the announcement. If the epithet "irresponsible" is to be flung at science reporting, certainly this needless play on fear deserves it. But it should be applied where it belongs — to the university publicist, not to the news writers who assume that the university was issuing a reasonable warning as an act of public service.

In each of these cases, knowledgeable scientists did not issue the announcements. Indeed, they weren't even consulted in the third instance. Nevertheless, the public, including editors and writers who receive the announcements, will tend to assume these have professional authority behind them. At the least, this points up a need for scientists to take a closer look at what their insitutions and funding agencies are telling the public about their work and about science generally.

Fluffing the Prestige Pillow

But scientists and engineers aren't guiltless either. As concern over funding and public image has grown, so has pressure been put on some learned societies to indulge in a little "professional PR." A decade ago it was considered indecent for scientific societies to go around in a Hollywood manner trying to promote themselves and some of their people. But for the past few years, I've been receiving some rather interesting phone calls, and I am not quite sure how to respond to them. Typically I pick up the phone and someone will say, "Bob, have I got something hot for you." Not recognizing the voice, I will put on my best Yankee manner and ask, "Do I know you?" The voice will reply: "No, you don't know me, but have I got a story for you. Dr. So and So, president of Such and Such Society, is coming to your town and we want to give him exposure. Wouldn't you like to interview him about problems with the environment (or sewage, or food, or war and peace, or whatever else seems topical)?"

This, I think, is professionally irresponsible. And it puts science reporters in an uncomfortable spot. We can deal with the Union of Concerned Scientists on one side of an issue and, knowing that bias, can then deal with the other side. But when the bastions of professional purity and objectivity begin to worry about budgets, jobs, and image to the point of reducing themselves to song-and-dance, where can science writers turn for objective background on scientific developments?

Our search for reliable facts is hampered in still another way. There used to be a number of science-based companies who had public information operations staffed by people who knew the business and could work very effectively with a writer on a technical story, even referring the writer to work done elsewhere while keeping their companies' commercial interests in the forefront. Now one often gets an employee of some PR firm who can't explain the technology and, what is worse, is pushing a second-rate story. A particularly blatant case is that of a release that arrived explaining an energy-saving invention in terms that sounded like perpetual motion. When this was pointed out to the PR agency executive, he said he didn't understand the thing but the story was important and I should run it. He did give me the name of the scientist who did the work so I could check with him. The invention turned out to be perfectly reasonable, and the scientist agreed that the release had made it sound foolish. He explained that the PR consultant had insisted it had to be "glamourized" or the press would ignore it.

This trend has hit government, too. I recently asked a long-time acquaintance why the press material from his agency had deteriorated into fluff and hype. It is a scientific agency of stellar reputation whose press releases had been substantial and informative. He explained that technically-knowledgeable information specialists, such as himself, had been put in the background by a change of management that brought with it a philosophy of public relations emphasizing "favorable exposure." Thus fluff that suggests catchy stories replaced substance.

It has been encouraging to see scientists taking the need to communicate with the public through the press more and more seriously over the past couple of decades. But when a misplaced zeal for "exposure" takes over, genuine communication suffers. Scientists and their institutions need to think more carefully about what they actually are saying to the press.

The press is an imperfect instrument. But used with care, it can be a powerful medium for evolving better public understanding of science and technology. And scientists might be reminded of an apt cliché — "garbage in, garbage out." □

A Pound of Flesh

Steve Babson, a freelance writer living in Detroit, is the former managing editor of Popular Economics Press. *He has taught economics at the University of Massachusetts Labor Institute and at the Boston Community School; and he is a frequent lecturer for the United Auto Workers.*

Suppose Barry Bosworth, former head of the Council on Wage and Price Stability (C.W.P.S.), was kidnapped after one of his speeches attacking workplace health and safety regulations as "inflationary." Suppose the kidnappers demanded $6 million or they'd do the young fellow in. And suppose efforts to rescue Bosworth failed, leaving ransom as the only option to save his life.

If given the chance, Bosworth would no doubt argue that $6 million isn't too much to pay for his life. But his own technicians at C.W.P.S. would first have to weigh his emotional pleading against economic calculations Bosworth himself had established. Is Bosworth *really* "worth" $6 million, they'd ask?

C.W.P.S.'s cost-benefit analysts would first locate Bosworth's pay stubs. They'd find he was worth, say, $50,000 a year. Then they'd estimate his "useful" life — how long he would earn such princely sums. If Bosworth can be expected to make that salary for the next 28 years, he'd be worth 28 times $50,000 or $1.4 million. Other formulas for determining Bosworth's monetary worth give different results, but they're all well below $6 million.

The experts would presumably be disappointed — how could kidnappers demand $6 million for a man who isn't even worth $1.5 million? Such an inflationary demand would have to be refused. After all, the cost of ransom is greater than the benefit of saving Bosworth's life.

Our fable ends, and so, alas, would poor Bosworth.

As improbable as it sounds, this little tale actually highlights a very real ongoing story. It differs from the fable in only two respects: first, for the high-priced bureaucrat whose life is on the line, substitute all of us — workers, bosses, and consumers; second, instead of unknown kidnappers as the killers, substitute deadly workplace chemicals, lethal drugs, and unsafe cars. You now have the outline of a real-life scenario acted out repeatedly in government agencies and corporate board rooms.

Consider, for example, hearings held by the federal Occupational Safety and Health Administration (O.S.H.A.) on proposed safety standards for America's coke ovens. This process of transforming coal into coke heats the coal to over 2,000° F for up to 16 hours; the coal gives off hydrocarbon gases known to cause lung cancer. The remedies are clear: engineering controls and improved work practices that would cost about $200 million a year and prevent immeasurable pain and suffering for thousands of steelworkers.

Enter Barry Bosworth and the Council on Wage and Price Stability. The proposed standard, Bosworth argued, is inflationary and should be rejected.

Inflationary? C.W.P.S.'s argument, at first, seems simply misinformed. Didn't O.S.H.A.'s economists peg the standard's estimated impact on the consumer price index at only .01 per cent? And didn't C.W.P.S.'s own research indicate the standard would save 109 lives a year? That's a low estimate by all other accounts, and one that ignores the many thousands saved from physical suffering and mental anguish; but still, that's 109 *lives*. So what's C.W.P.S. talking about?

This: each of those 109 steelworkers, according to Bosworth, is "worth" only $200,000 to $500,000; but the cost of the engineering controls and work practices necessary to prevent the risk of cancer is somewhere between $1 million and $9 million per worker saved. Hence, the controls aren't worth it — the costs outweigh the benefits.

Fortunately, O.S.H.A. rejected this logic. But Bosworth's "scientific" efforts to monetize human life and compare it (unfavorably) with other costs isn't an isolated effort. Others make the same effort, with equally dismal results.

Tin Lizzy

The National Highway Traffic Safety Administration (N.H.T.S.A.) has developed its own method for measuring human life in monetary terms, resulting in N.H.T.S.A.'s 1972 study, "Societal Cost Components for Fatalities." Any safety measure's cost, the automakers argued to N.H.T.S.A., should be measured against the value of each life saved. N.H.T.S.A. estimated the social cost of a single death at $200,725: $173,000 in lost productivity; $1,125 in medical costs; $16,600 in funeral, legal and various other costs; and $10,000 for the "victim's pain and suffer-

ing." No explanation was provided in the report of how the pain and suffering of a dying person was pegged at $10,000.

The Ford Motor Co. then relied on this N.H.T.S.A. figure in its response to fuel-tank safety standards proposed by the federal government. A memo sent by Ford to N.H.T.S.A. in 1973, entitled "Fatalities Associated with Crash-Induced Fuel Leakages and Fires," argued bluntly that the proposed fuel-tank standards would cost three times more to implement than the estimated "savings" they'd generate. How were "savings" estimated? Ford's safety engineers simply took the N.H.T.S.A.'s figure of $200,000 a life and multiplied it by the estimated number of deaths and injuries a particular standard would prevent; their computation: only $49 million saved. Since the standard in question would mean additional costs of $137 million (or $11 per car), the standard would, in the words of Ford's safety engineers, yield "implementation costs far outweighing the expected benefits."

Hidden Hands

Some individuals within C.W.P.S., N.H.T.S.A., and the Ford Motor Co. may question this practice of "monetizing" human life and comparing it (unfavorably) with the commercial priorities of large corporations. But overall, these three organizations have endorsed the concept that saving lives is not only unprofitable in some cases; it can also be "inefficient" — even inflationary. Health and safety standards, in this view, add burdensome production costs and make U.S. cars and steel less competitive with imports. The market's "hidden hand," then, is to be the ultimate arbitrator in these matters of life and death — and cost-benefit analysis is simply the best way to divine the market's verdict.

Many in O.S.H.A., the consumer movement, and organized labor regard this approach as a flagrant bit of mystification. Cost-benefit analysis, these critics point out, is a useful approach to problem-solving *so long as* the problem in question can legitimately be reduced to quantifiable, and therefore comparable, elements. But problems arise when one or more of the elements can't be quantified. The value of a human life, they argue, is one such element, and all efforts to reduce it to monetary terms have given hopelessly varied and subjective "valuations."

If, for example, we use future earnings as our life-valuing basis, we'd have to conclude that retirees, women, minorities, and the handicapped are all "worth" less than the well-paid, mostly white males who've devised Bosworth's life-pricing method. It should be obvious that what's being measured here isn't lives but the value of their (unequal) earnings.

We could try the many alternative criteria proposed by Bosworth's peers: hazard pay, life insurance premiums, or per capita health expenditures. Surely, it's argued, these many price tags placed on human life measure something. Indeed they do — they measure the imperfect knowledge and unequal bargaining power of the classes and individuals scrutinized. The value of their lives is another matter. Since much of human existence — its activity and its meaning — still stands outside the marketplace, its "value" can't fully be measured in market terms.

Bosworth's cost-benefit analysis is much more than a conceptual aberration. It's the ultimate articulation of the market's fine impartiality — the "hidden hand" values all things in the same terms, whether people or inventory. That the market's "hidden hand" is ultimately human doesn't occur to many. Owners and managers are so consumed by their firm's day-to-day struggles they can't help but regard the market as a "natural" force, no less demanding and unpredictable than the weather. For the cynical few who know better, the "hidden hand" is always a useful fall guy when it comes to keeping your own hands clean. In either case, Bosworth doesn't see himself as cruel; just "efficient."

And the analytical language magically conceals questions of social power and contending priorities: workplace health and safety regulations are "inefficient" — even as European and Japanese companies engineer safer cars and steel mills. Social services are "inflationary" — but military spending isn't. Likewise, a shorter work week is "unproductive"; full employment is "disequilibrating"; and socialized production-for-human-use, as an alternative to the present production-for-profit, is simply out of the question. So long as we measure the feasibility of saving lives in market terms, the resources available for improving workplace and consumer safety will be limited to what corporations can "spare" after banking away their customary rate of return.

But what, after all, is the alternative? We cannot resolve all problems at once; they must therefore be "prioritized." And we need methodological tools to do this, so why can't cost-benefit analysis be used?

It's basically a question of appropriateness. Comparing explicit options for well-defined objectives is a legitimate use; comparing the "value" of a human life with the cost of saving it is not. We do need to define our human objectives, and this will require active public debate to establish a humane choice of goals. The implementation of agreed-upon goals might then employ a full range of analytical tools, as long as moral and social values are fully respected. □

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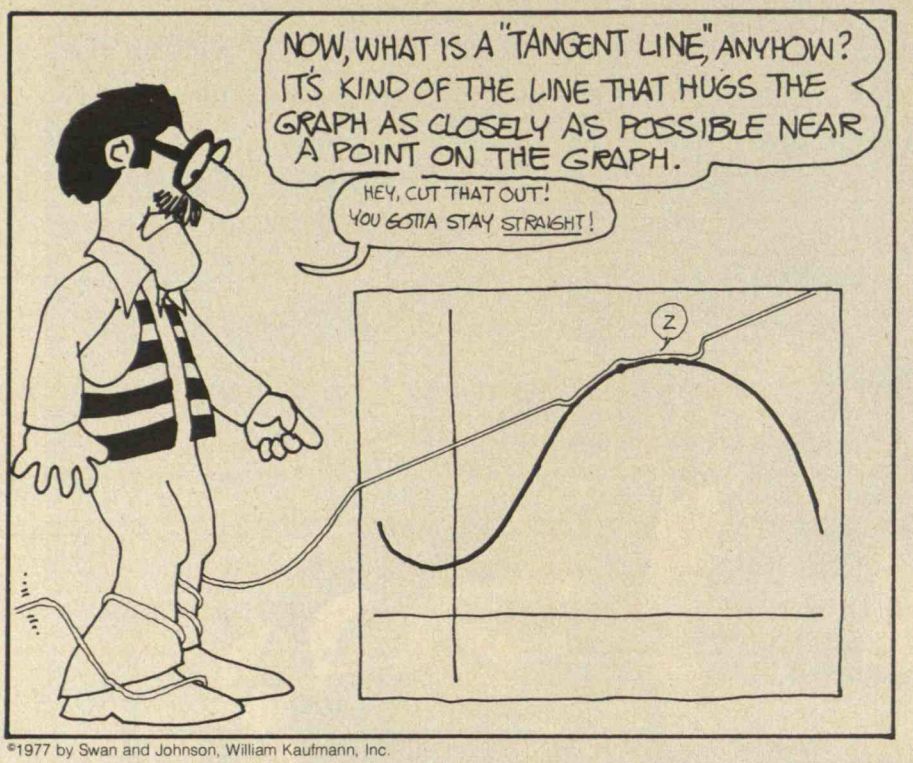
Beware: Math Gets in Your Hair

Prof. E. McSquared's Original, Fantastic, and Highly Edifying Calculus Primer
Howard Swann and John Johnson
Los Angles, California: William Kaufmann, Inc., 1977, 214 pp.; $7.95 (paper)

A Fortran Coloring Book
Roger Emanuel Kaufman
Cambridge, Mass.: M.I.T. Press, 1978, 285 pp.: $6.95 (paper)

Reviewed by Joan Baum



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Except for some references to logic and number games, Charles Dodgson kept Alice's sense of wonder away from the land of math, and most people since have maintained that distance. Nothing, it would still seem, could be less receptive to the play of fantasy and wit than a text on scientific programming or differential calculus. Yet here they are: two recent additions to the growing trend of intellectual comics — cartoon paperbacks trying to teach mathematics with delight.

The new "documentary" comics, as they are also called, are designed to introduce a sophisticated audience to technical or unfamiliar material. Aiming for the head through the eye and the ear, these intellectual comics put on an antic disposition in order to seduce the fearful and the diffident. They assume a readership appreciative of clever caricature and design, amused by outrageous puns, and charmed by the wiles of self-deprecating irony. Intellectual comics on calculus and FORTRAN, however, deliver the ultimate test, for there is no subject more feared than math.

In attempting to make a difficult subject seem effortless, both books succumb to a circular argument. Math can indeed be understandable and fun, but only for those somewhat knowledgeable; those with a good grounding in algebra; and those disposed to learn. Students who know nothing about differentiation or computers will be drawn, but eventually abandoned, probably to confusion and resentment. No amount of punning and satire can obviate the need for clear definitions and rules neatly set out. No amount of humor can replace detailed exposition, repetition, and timely practice exercises. Ironically, in the Kaufman book, the most helpful section is the eight-page summary at the end, 'Fortran in a Nutshell' (guess what the picture is), where key points and symbols are neatly tied up, with none of the self-conscious joking that dogs most of the book. For the uninitiated, or for those whose sense of humor is less parochial than Kaufman's Marx brothers' imitations, the comedy may be seen to substitute for explanation: ". . . don't jump from Outside a DO loop to Inside the loop unless your insurance premiums are paid up." Professor McSquared and gang are much more successful both at instruction and wit. Yet, both books move too fast.

Signs of Decline

It is clear, however, why the books exist. They reflect a sense of inadequacy about math texts and about math teaching at the lower undergraduate levels, where math is required, where majors are dropping off, and where S.A.T. scores continue to show decline. In *Why Johnny Can't Add* (1973) Morris Kline imputes math teachers and their pompous, boring books for this decline in interest and performance. While there are notable exceptions to the accusation, the general condition would seem to support Kline's view. Many a frustrated novice has reason to be put off by math texts with their Latinate sentence constructions, undefined polysyllabic terms, arrogant tones, unwarranted assumptions, and cold imperatives. The passive voice dominates. Directives rule. "It will be remembered . . ." charges one; "Of course, it will take time, but . . ." remarks another as the author blithely skips to illustrating complicated exceptions to the general rule.

Many texts talk down or treat problems clearly beyond us in which they give "hints" about processes or maneuvers that can be intuited only by the already secure. They put answers in the back so that when we give up on the process we can forget that getting there is what math is all about. In addition, as many an angry student can attest, the answers are sometimes incorrect or given in a form different from what was introduced in the classroom. In the Kaufman book, therefore, where the level is established by the opening line — "A computer is like your mommy's bureau draws" — it is unfortunate to find unexplained sigma notation, an undefined Computed GO TO, and the offerings at the end of complex problems for extra credit that relate to infinite series and number theory.

Most math texts also show beginning students little relation between one topic and another. Formulas and subjects come and go with no interconnectedness: if it's Tuesday, it must be conic sections. Russell Baker complained not too long ago of having sat quietly in an algebra class one day, minding his own variable business, when wham! PI in the face. No warning, no explanation. Students who fear math

and cannot follow interpretations in class often despair when they turn to their last resource, the text. Then, thwarted in their efforts to hack through the English, they often simply memorize the proofs-of-the-week. On tests, many students cannot choose proper formulas except by psyching out the sequence of questions: this is #2 so it must be the limit-comparison test; that came before alternating series and conditional convergence. In many schools, students don't even understand the basic English vocabulary — "continuous," "convergence," "instantaneous," "interval."

What is particularly refreshing about the *McSquared* book is that it does not seek to be a regular text but rather an introduction to one. "Beware!" it warns in the opening line, "This is a Genuine Calculus Book." Yet it also presents itself as an "experiment" and a prelude to more traditional fare. It recognizes that its "fantasies" are "dependent on the energy and imagery of our contemporary culture." Unlike the *Fortran Coloring Book* (the reason for this title is unclear) where humor is often forced and dated by references to Milton Berle, Watergate, and Henry Morgan, the calculus primer's reliance on visual wit more than on dubious puns ensures its greater success in explaining a subject that is "relatively timeless."

The pictures in *McSquared* are not merely decorations or asides, but recurring representations in a narrative about difficult concepts. Cartoon characters, animals, and inanimate objects move and talk in illustration of the three main sections of the book: (1) FUNCTIONS, which asks "What kind of a logical framework can we use to discuss graphs?" (2) LIMITS, which asks "How can you logically say that a graph has a nice smooth curve rather than one that jumps around?" and (3) DERIVATIVES, which asks "When is the curve of a graph smooth enough so that you can find a line tangent to the curve?" Little figures, often squished precariously in the frame, are true comic helpers in the instruction. They comment when the going gets rough, as it does in section (2), by forcing the sometimes ostentatious Professor McSquared (a caricature by Johnson of mathematician Howard Swann) to explain himself with other words, other analogies, other pictures and graphs. They also serve comic relief by being loony, zany, cynical, and sometimes obtuse, encouraging the overwhelmed reader, as comedy always does, by making him superior to the characters. At particularly knotty points, they suggest that McSquared has a screw loose, or they mock the seriousness of the subject: two "thetas" argue over which one is "bara." Piggy asserts that his cousin Britannia waives the rules. Still, at the most difficult points, trying to explain and visualize that delta-epsilon process and proof, for example, no amount of horse-pig-or duck-play by the "irreverentyrannical wierdoverly punkids mosterowdy-clowns" can do the job. The valiant effort can at best attract some who will be moved to go on.

What's A Math Book to Do?

A good math book should contain four basic elements in proportion to its level of instruction: (1) clear definition in English of key terms and symbols of notation; (2) explanation of fundamental concepts and theorems in everyday words with analogies and appropriate diagrams; (3) sufficient illustration of sample problems that show working out in formula and in prose; and (4) exercises that encourage practice with proofs and that show application to problems in the real world, rather than exercises that call only for manipulations of formulas where the major difficulty often turns out to be arithmetic or algebra. *McSquared* is particularly good at holding back definitions until it attempts explanations and illustration. But the concepts are difficult, and notation and procedures are more various than *McSquared* allows; students encountering max/min problems and instantaneous velocities for the first time need more space and time. *McSquared* may stimulate some otherwise-reluctant students to go on, but into what? They will need more "out there" urging them on with charm and intelligence to persevere.

The idea of presenting math with whimsy and wit is not new, although the idea of doing it in comic-book form is. Back in 1914 (with 27 printings by 1958), Silvanus P. Thompson's little gem *Calculus Made Easy* boasted a "very simplest introduction to those beautiful methods of reckoning which are generally called by the terrifying names of Differential Calculus and the Integral Calculus." Its epigraph — "what one fool can do, another can" — and its irreverent tone toward an establishment hoarding mathematical secrets create in the early chapters an excellent balance of exposition and charm. But it does not do what it claims — make the subject "ridiculously easy." And as the book goes on, it becomes clear that some things — such as ordinate systems and slopes — are not ridiculously easy.

The question of comedy as an aide to comprehension has to do not only with form and style but also with magnitude. Too much of a funny thing becomes palling, and nothing dates so fast as humor, much of it regional, obvious, and derivative (no pun). But for those who don't mind a bumpy ride with an oddball assortment of intrusive innocents abroad, *McSquared*'s oversize comic book should provide enough ground experience to whet the taste for travel later on. They also provide T-shirts.

Joan Baum is associate professor of English at the City University of New York and a student of math. □

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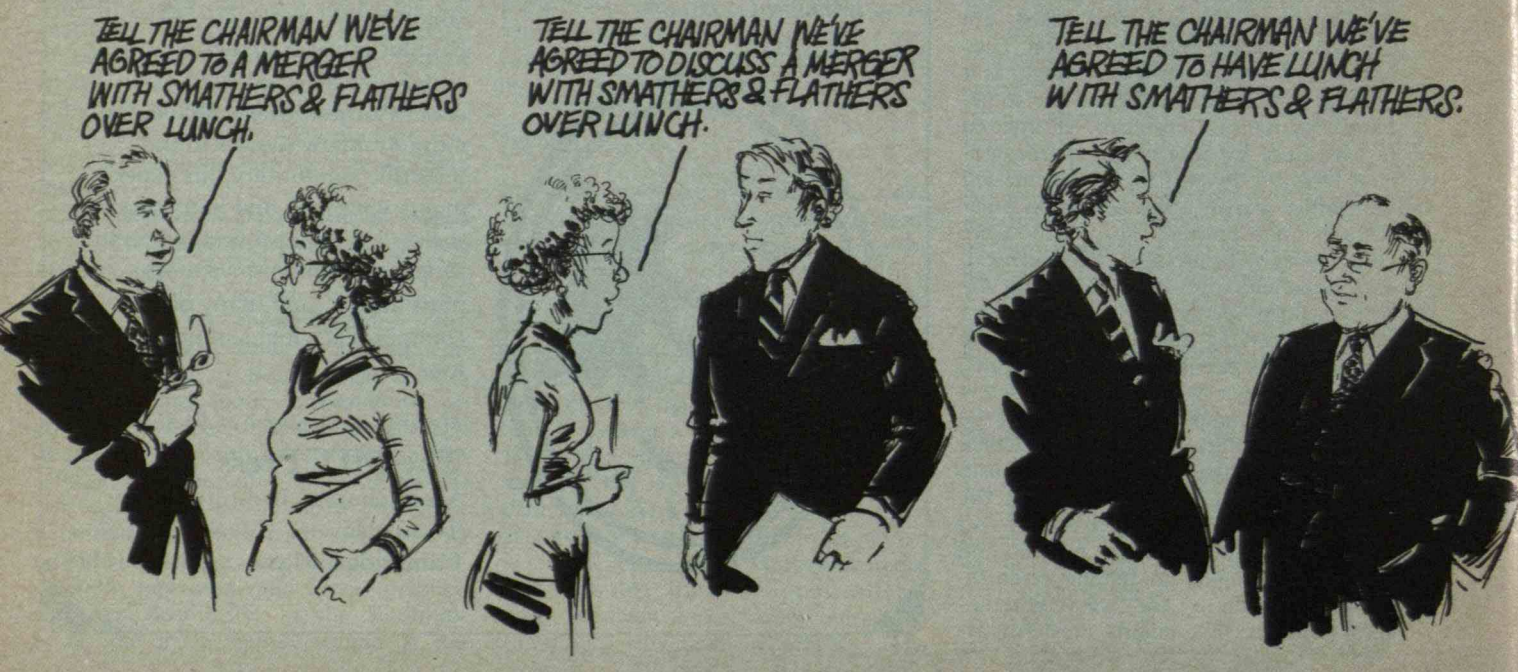

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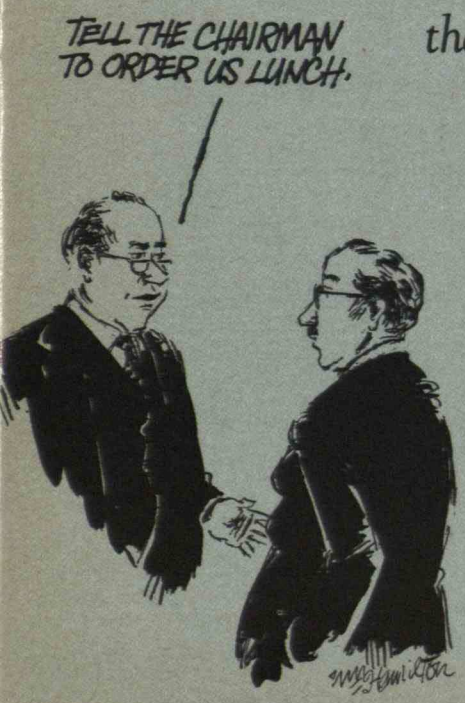

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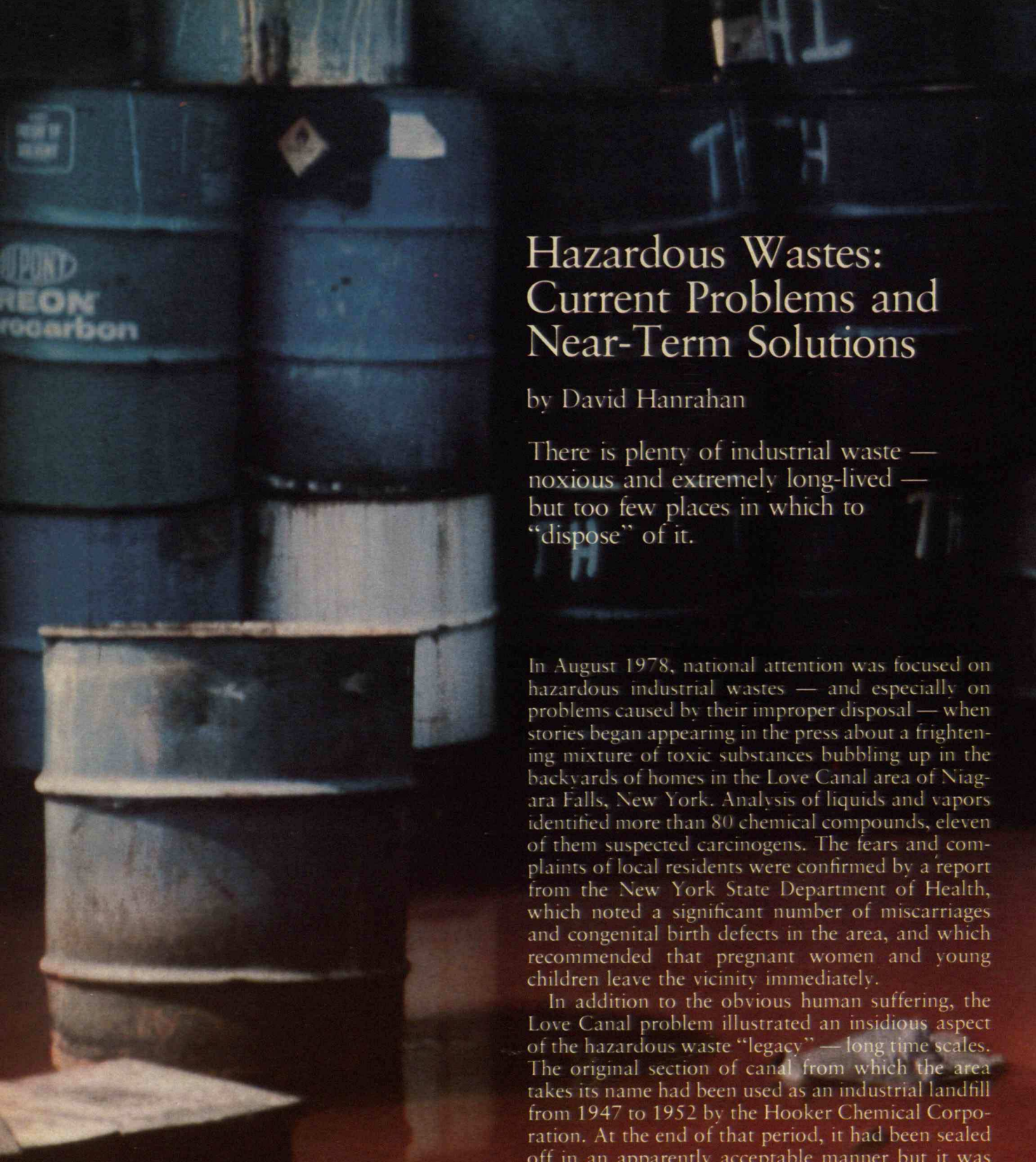


Hazardous Wastes: Current Problems and Near-Term Solutions

by David Hanrahan

There is plenty of industrial waste — noxious and extremely long-lived — but too few places in which to "dispose" of it.

In August 1978, national attention was focused on hazardous industrial wastes — and especially on problems caused by their improper disposal — when stories began appearing in the press about a frightening mixture of toxic substances bubbling up in the backyards of homes in the Love Canal area of Niagara Falls, New York. Analysis of liquids and vapors identified more than 80 chemical compounds, eleven of them suspected carcinogens. The fears and complaints of local residents were confirmed by a report from the New York State Department of Health, which noted a significant number of miscarriages and congenital birth defects in the area, and which recommended that pregnant women and young children leave the vicinity immediately.

In addition to the obvious human suffering, the Love Canal problem illustrated an insidious aspect of the hazardous waste "legacy" — long time scales. The original section of canal from which the area takes its name had been used as an industrial landfill from 1947 to 1952 by the Hooker Chemical Corporation. At the end of that period, it had been sealed off in an apparently acceptable manner but it was not until more than twenty years after the landfill had been sealed that several wet winters led to chemicals being floated to the surface.

Incidents as severe as Love Canal are rare. But the discovery of environmental damage from dumping of toxic wastes, or the posing of substantial threats to health and the environment from improper handling of wastes, are almost everyday occurrences. Further examples (taken from New England, but typical for the wetter regions of the United States)

Public opposition to "secure landfills" is easy to understand. Illegal dumping is one reason and the poor record of the disposal industry is another. The Silresim facility in Lowell, Mass. (shown here), is an example of both. (Photographs: The Environmental Protection Agency)

can illustrate other aspects of the broad hazardous waste problem.

In the town of Gray, Maine, a strange odor from the water led to the eventual discovery that wells in the area had been contaminated by seepage from a local hazardous-waste disposal site. The *Maine Times* graphically described the contaminants: "The smelly stuff in the wells was dimethyl sulfide, a toxic chemical used for industrial cleaning and paint stripping, also known to cause kidney and liver disorders. Half a dozen other chemicals were identified in the water including two industrial solvents, trichloroethane and trichloroethylene, the latter of which is known to depress the central nervous system, to cause mental confusion, nausea and gastrointestinal problems; it is related to liver and kidney disorders; and to top it all off, it is carcinogenic."

In Lowell, Massachusetts, an organic contaminant, toluene, reached high concentrations in the sewer system and in August 1977 some of the workers operating the system were overcome by fumes. Suspicion was focused on a waste disposal firm which had already been cited for violations of its operating license. This firm (Silresim Chemical Corp.) was declared bankrupt in December 1977 and subsequent inspection by state officials revealed 15,000 assorted drums of toxic wastes spread about the property. Many of these drums were corroded or leaking or had spilled out onto the ground. Among the wastes on the site were toxic chlorinated hydrocarbons, flammable solvents, corrosive acids and caustics, and toxic heavy metals. The director of the Massachusetts Division of Water Pollution Control summarized the situation as follows: "These wastes present several dangers. Should incompatible wastes mix because of tank or barrel rupture, fire or explosion could occur and/or toxic gases be generated. Second, storm runoff of the waste is causing continuing pollution of ground and surface waters. Third, if a major spill occurs, the water supply of the city of Lawrence could be seriously imperiled." The costs of cleaning up (which are being borne by the Commonwealth of Massachusetts) have already surpassed $1.5 million.

These three examples illustrate many of the major issues in hazardous waste disposal: the noxious character of the substances; the long time scales involved; the two main contamination paths (through surface runoff or through groundwater); the need for control of disposal operations; the high cost of cleanup; and the need for long-term monitoring and surveillance.

Federal and State Regulation

These issues are addressed in subtitle C of the Federal Resource Conservation and Recovery Act of 1976 (R.C.R.A.). The Act deals with "solid waste," which is broadly defined to include not only solids, but liquid, semi-solid and contained gaseous materials as well. Subtitle C recognizes individual states as the appropriate governmental level for the development of specific hazardous waste programs, but it lays out a number of general requirements. These include, for example, registration of waste generators and the development of a "manifest system" to track all wastes "cradle-to-grave" (from their generation, through their transport by licensed handlers, to final disposal at permitted facilities). Other requirements cover the construction and operation of treatment, storage or disposal facilities. The U.S. Environmental Protection Agency (E.P.A.) has published proposed regulations under Subtitle C, is reviewing comments, and will be publishing final regulations over the next year. Some find the Agency's pace a little too slow, however, and it has already been sued for its failure to meet the original statutory guidelines.

R.C.R.A. defines "hazardous waste" in a very broad manner: "a solid waste . . . which because of its quantity, concentration or physical, chemical or infectious characteristics may:
a) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or
b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."

The greatest amount of controversy involves the E.P.A.'s proposed criteria (as required by R.C.R.A.) "for identifying the characteristics of hazardous waste, and for listing hazardous waste . . . taking into account toxicity, persistence, and degradability in nature, potential for accumulation in tissue, and other related factors such as flammability, corrosiveness, and other hazardous characteristics." There is no gradation in R.C.R.A. disposal regulations — every substance classified as hazardous is subject to the same strict control. (Some wastes, not necessarily non-hazardous, are now specifically excluded from the provisions of R.C.R.A. by E.P.A. High-level radioactive materials, for example, are covered by other federal laws.)

E.P.A.'s criteria include characteristics of the waste — if it is ignitable, corrosive, reactive or toxic (as determined by a series of tests and/or definitions), then it is hazardous. E.P.A. is also developing tests for radioactivity, infectiousness, phytotoxicity and mutagenicity. In addition, a waste is hazardous if it is listed as such for any of the following reasons: coming from certain sources, such as hospital departments; being generated by certain industrial processes; containing any of a large number of substances already acknowledged to be toxic (including selected pesticides, certain "priority pollutants," and bacterial, fungal and viral agents).

Given the breadth of these criteria and listings, the EPA has estimated that somewhere between 10 and 15 per cent of all industrial waste will be classified as hazardous. This would imply 35 to 50 million tons (wet) of hazardous waste, nationwide, each year. In

The Costs of Doing the Job

When the Environmental Protection Agency issued its draft regulations under the 1976 Federal Resource Conservation and Recovery Act (R.C.R.A.), it made some preliminary estimates of their annual costs to industry. These costs are based on detailed studies by E.P.A. of 17 industries which generate hazardous waste. They assumed the existence of a National Hazardous Waste Liability Fund, set up to assure continuous surveillance of all disposal sites — and remedial action if necessary — after closing.

One unresolved aspect of R.C.R.A. is the degree to which surface impoundments on the properties of many companies — which already comply with the requirements of the 1977 Federal Water Pollution Control Act — will have to be modified to meet R.C.R.A. standards. The Manufacturing Chemists Association estimates that further upgrading of such impoundments could by itself cost nearly $900 million not included in E.P.A.s estimates.

The same E.P.A. study projected a total of 10.8 million tons (metric) of hazardous waste generated in 1977. The average cost of technical treatment and disposal was put at $43.9 per ton and the average administration cost was estimated to be $26.2 per ton, for a total of $70.1 per ton. For service and retail industries, administrative costs could be several times the technical disposal costs.

These numbers are based on technology; they do not include any estimate for market factors. "A shortage of treatment/disposal capacity could significantly increase the costs reported here," says the E.P.A. report.

Present costs in the Boston area for disposal in an approved secure chemical landfill (in New York State) are of the order of $100 per metric ton. This high price is attributed to long-distance hauling and to the high demand for available capacity. —*D.H.* □

addition, other non-manufacturing sources of hazardous waste include waste oil from service stations, ash from power plants, waste ordnance, dredged materials and contaminated debris (mostly due to oil spills).

Needless to say, there has been a great deal of criticism of these proposed regulations, and they may be revised in several important details before the final versions are promulgated.

Defining and classifying wastes pose one set of regulatory problems; how to dispose of the wastes comprise another. The E.P.A., as charged by R.C.R.A., is thus developing design criteria for treatment, storage and disposal facilities. The approach taken in these regulations is basically one of setting design and operating standards, rather than establishing ambient air and water quality levels, and they are general-purpose (for all facilities) as well as specific for different types of disposal. The scope of these regulations will also be broader than most existing ones because the new regulations are written to include firms which at present dispose of wastes (or stockpile them) on their own property. Such on-site disposal accounts for about three-quarters of present waste disposal, and is rarely directly covered by state waste-disposal legislation.

The most common and most troublesome type of disposal is "landfilling" (i.e., land *dumping* in some form). The E.P.A. regards groundwater contamination as the most serious danger posed by such landfilling, and espouses a philosophy of total containment for wastes placed in a landfill. The justification for this lies in the lack of any real knowledge of the transport, degradation and synergistic effects of complex pollutants in the ground.

Total containment poses several technical and operational problems, particularly for those areas (such as the northeastern United States) where annual rainfall exceeds evaporation or where geological conditions are unfavorable. In any case, the new requirements proposed for land disposal are very strict, and there are few sites anywhere in the nation which will be acceptable as "secure landfills" under the new regulations.

At secure landfills which do exist, disposal costs are already much higher than the costs of dumping, and their limited capacity may drive the price of legitimate disposal even higher. This will result in a significant burden on industry, although the precise economic impacts, sector-by-sector, are uncertain.

The shortage of secure facilities is not due to unsolvable engineering problems or unacceptably high development costs. Local opposition to the siting or expansion of landfills is preventing the construction of new capacity, despite the efforts of several disposal companies. It is not simply that sites are unavailable; a number of companies own land on which they wish to open new facilities. In many states, local municipalities have some power to control development through zoning or through Board of Health regulations, and these powers have been used to block the plans of the disposal companies.

The reasons for public opposition are easy to understand. For one, much publicity has been given to the horror stories of illegal dumping; and for another, the disposal industry in general has a very poor record in the eyes of the public. The Silresim facility in Lowell, Massachusetts, noted earlier, is an example of both. It is true, of course, that real risks and problems are associated with a secure landfill (as with any large industrial project) and that tangible benefits to the host community are usually minor. The most upsetting aspect to many people is the extreme longevity of the problem — many of the substances put in a hazardous-waste landfill are essentially non-degradable.

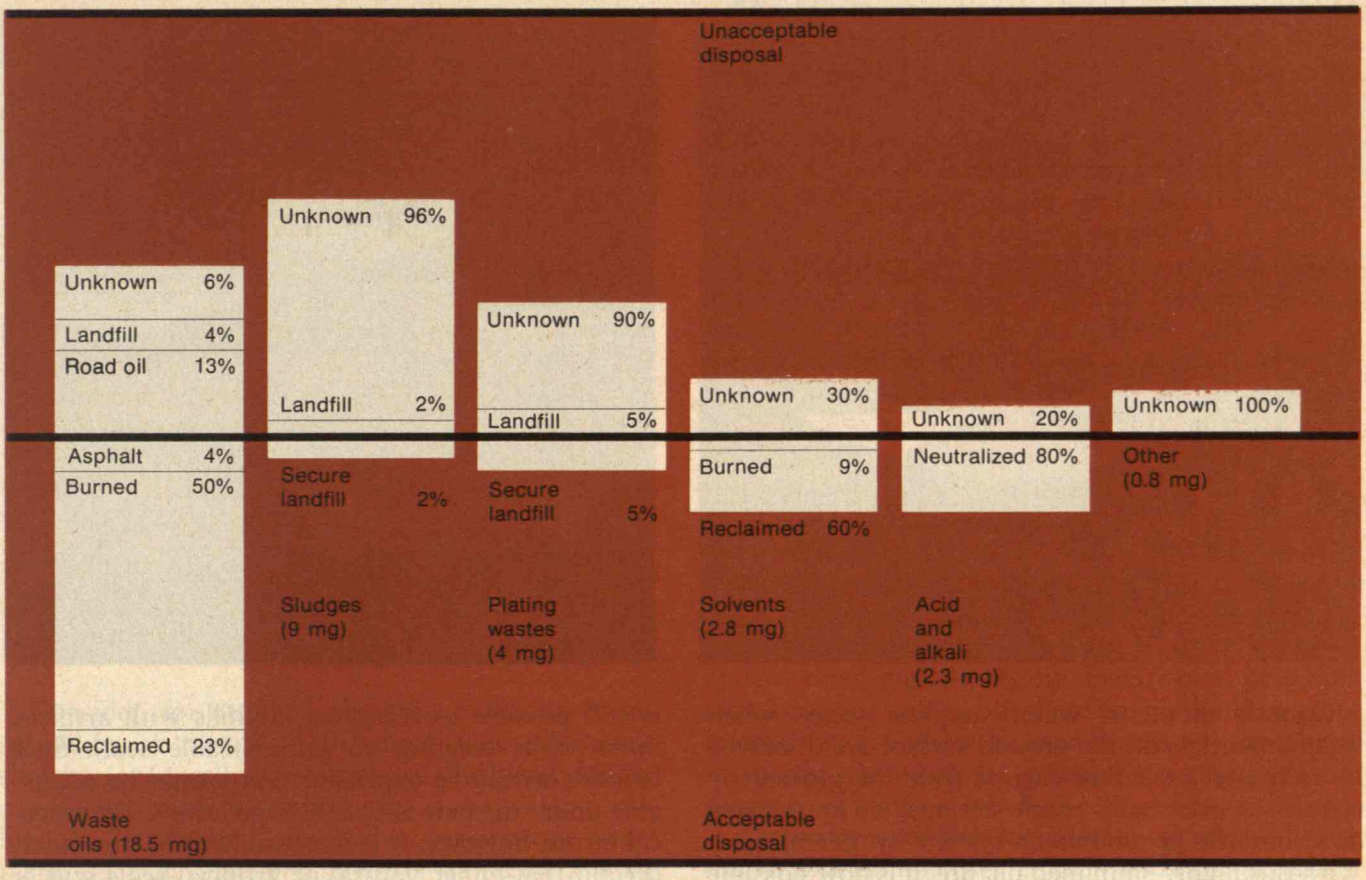
Despite this apparent stalemate, industry continues to produce growing stockpiles of waste, and has called on state governments to intervene. (The results of a 1976 study in Massachusetts, shown at the right, give an indication of present patterns of disposal.) Their incentive to act is a vision of all available permitted capacity being filled, and of large quantities of hazardous waste having no place to go. That such a situation appears quite possible is frequently blamed on the federal emphasis — regulation of wastes, to the relative neglect of practical management problems.

The six New England states, for example, have recognized their need to become involved in the management of hazardous waste. There is also a joint advisory group, under the auspices of the New England Regional Commission — a regional developmental arm of the U.S. Department of Commerce. The advisory group is charged with the coordination of the individual states' efforts, as well as with investigation of where multistate approaches (taking advantage of economies of scale in treatment or disposal facilities) might be appropriate.

Disposal in Landfills

A fundamental principle of good waste management is that disposal should be regarded as a last resort, to

Waste quantities and disposal methods ("acceptable" and "unacceptable") were surveyed in Massachusetts in 1976. (Source: G.C.A. Corporation.)

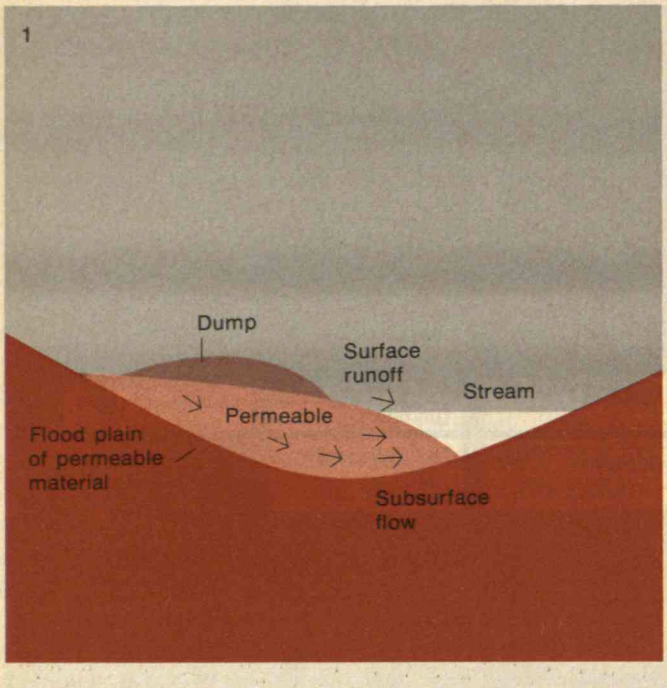


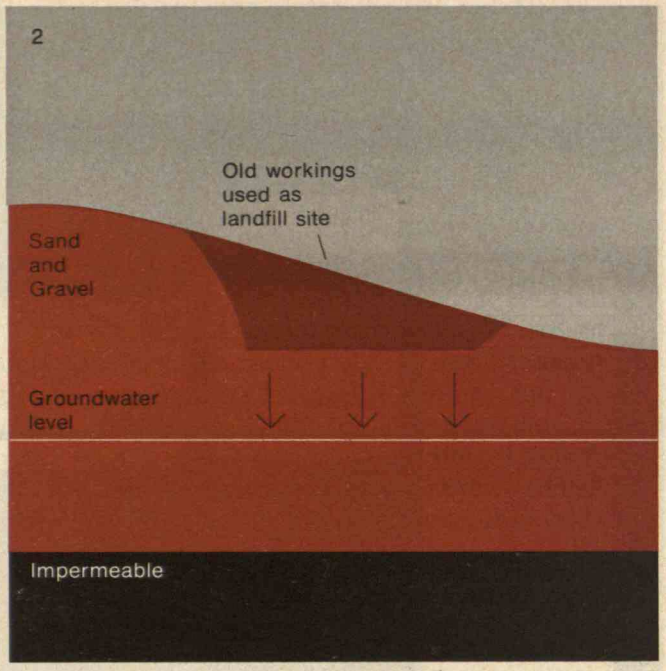
be employed when all practical efforts have been made to reduce, recycle or recover the waste materials. Implicit in this approach is a view of the problem as one of materials flow rather than of waste disposal. It also provides a framework for examining the varying and sometimes conflicting requirements of other federal regulations, the economic effects of raw material price changes, process alterations, and so forth. But at-the-source waste reductions, and enlightened recycling and reuse, will not play major roles until some future time. They may be desirable, but institutional inertia alone could cause significant delays. Moreover, there will always be a certain amount of industrial waste for which a landfill will be the final destination — even after all possible pretreatment — and there will also be a need for some capacity to accept spill debris and other contaminated materials.

In practical, here-and-now terms, therefore, the most urgent problem to be considered in state management planning is the development of new landfills. And it is essential that the lessons of "Love Canals" be applied such that public health and environmental protection are assured.

Consider some of the geological aspects of landfill siting and their bearing on possible water contamination. For simplicity, it will be assumed that the many varied and mixed layers of the soil can be represented by a few clearly defined strata, and further that these strata can be classified as either permeable or impermeable (although the distinction in reality is purely one of degree). It must be noted that the important parameter is the gross permeability of the material on a relatively large scale. (Although a piece of rock may be totally impermeable, for example, a large formation of the same material — if highly fissured — may permit a very large flow.)

An aquifer is a formation which holds a useable quantity of water. For the present purpose, it can be regarded as a permeable layer underlain by an impermeable one. Where the groundwater level in an aquifer intersects the surface there will be springs or a steam, and there will be a slow flow of groundwater toward a spring (the velocity depending on several factors, including the permeability of the aquifer.) In wet regions of the country, there will be a continual replenishment of the water by precipitation which has percolated into the ground.





Contamination of water supplies occurs when waste materials on the ground surface are dissolved by rain and are either carried over the ground by runoff (to eventually reach streams) or are carried down to the groundwater system by percolation. With this highly-simplified picture, it is now possible to review some possible types of landfill sites and their potential for contaminating water supplies.

Figure 1 (*above*) shows the simple common river-side dump — which guarantees stream pollution. Unfortunately, there are too many instances of this type of dump (which often takes advantage of supposedly worthless swampy land). Another common site for land disposal is an old sand or gravel pit. Holes are left from quarrying, and it appears to make good sense to refill them with waste material. However, gravel is the prime example of a permeable material, and any water which seeps through the waste will very quickly make its way down to the groundwater (Figure 2). There are different types of wetland; some are acceptable as landfill sites, while others are quite undesirable. The extremes are illustrated in Figures 3 and 4.

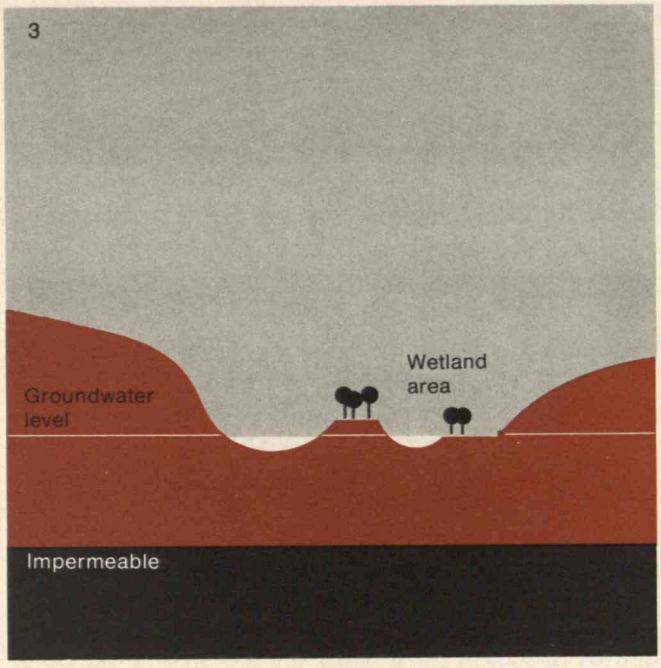
An ideal site for a landfill is shown in Figure 5. The groundwater is very deep or there is no aquifer under the site; there is a thick band of highly impermeable soil under the area; and the ground slopes generally away from the site so that surface water does not run across the landfill.

Even under less-than-ideal geologic conditions, it is still possible to construct landfills with artificial liners (thus creating an impermeable seal). Such landfills would be expensive, but would be acceptable under the new R.C.R.A. regulations. (In practical terms, however, it is impossible to be absolutely certain that either natural or artificial seals will be totally impermeable.)

Unfortunately, the great majority of landfills which now accept industrial waste have neither sufficient natural protection nor adequate artificial lining, and thus will soon be in violation of federal law. The E.P.A. recognizes that an interim period will be needed for operators to bring their facilities up to standards, but there is no doubt that many existing facilities should be closed to anything classified as "hazardous waste."

The first stage in groundwater contamination is the development of a leachate — a collected liquid which is either a mixture of noxious substances or which has some of these in solution. The production of leachate can be minimized by requiring all wastes to be in a solid or semi-solid form, which may mean that the liquids have to be mixed with absorbent material. The quantity of leachate can also be greatly reduced by designing for proper drainage around the site and by sloping finished surfaces so that the amount of surface runoff entering the landfill is minimized. The quality of the leachate is affected, of course, by the solubility of the materials in the landfill.

Figure 1: The riverside dump — a site guaranteed to pollute.
Figure 2: The "recycled" gravel pit — another sure polluter.
Figure 3: An unsuitable wetland site.



Consider, for instance, the great variation in resolubility of metals in different water-treatment sludges (an excellent example of the need for an overall materials flow approach to the waste problem). A "traditional" method of wastewater treatment, such as lime precipitation of metal plating wastes, can produce a relatively stable semi-solid sludge. A switch to more advanced methods, such as reverse osmosis, will produce much cleaner effluents but a very unstable sludge which may contain highly soluble forms of the metals. Changes in water quality standards can thus have a major effect on hazardous waste disposal problems.

In order to make landfills an acceptable option, at least until more enlightened methods are widely adopted, R.C.R.A. focuses on "total containment" — preventing leachate from reaching the groundwater. The E.P.A. will try to implement this philosophy in the permit program (as required by R.C.R.A.) for the design and operation of landfills.

To achieve containment, two liner designs (*shown on p. 30*) are suggested by the E.P.A., with a certain discretion allowed the permit applicant for site-specific factors. (There is also a third possible design, not shown, for arid areas with good geology.) Although such designs are considered quite secure, there can be no absolute guarantee that material will never percolate through the liners. It is necessary, therefore, to examine the potential effects of a hypothetical release from a "secure" landfill.

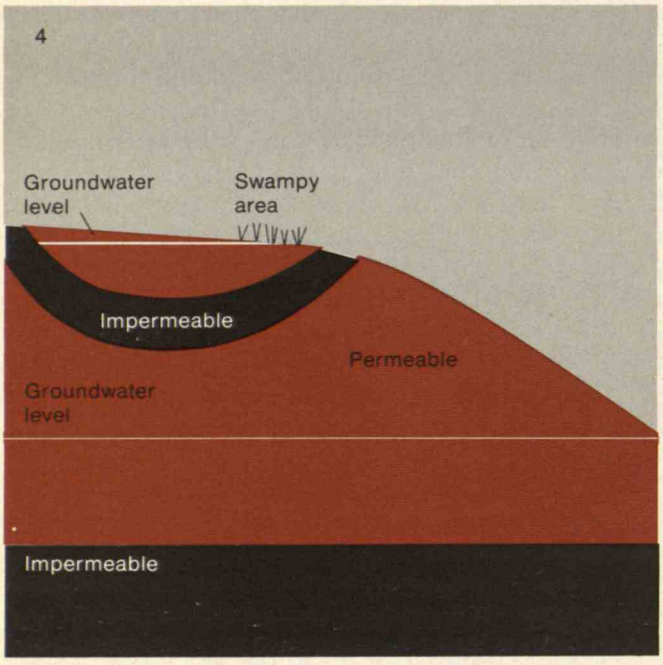
The first question is whether the release could be detected. The leachate collection systems which are required above and below the landfill liners will provide samples of the "liquor" collecting inside the landfill, and will allow for monitoring of the region directly below the landfill for any traces of the same liquor. In addition, there is a requirement for monitor wells in the groundwater below the site — one of which will be upstream of the landfill to provide samples of water from outside the possible zone of contamination. This monitoring system is intended to serve a dual purpose — to allow any possible contamination to be detected as early as possible, but also to provide proof positive to skeptics when no leachate is escaping.

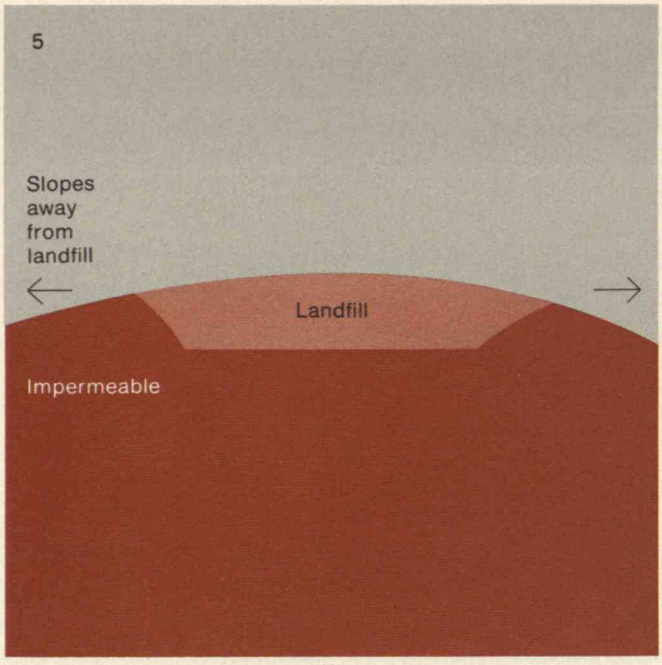
Assume that some quantity of leachate is detected in the collectors under the landfill. At this stage the contamination is still well above the groundwater level and the first reaction should be to increase the monitoring (installing new wells if necessary) and to locate and repair the leak. Digging out the wastes and working directly on the liners would be a very expensive last resort, but there are methods of grout injection which might be used to seal a suspect area. It should therefore be possible to minimize the quantity of material which is released from the site.

The progress of the slug of leachate released from the landfill cannot be predicted with any certainty. There are complex interactions between the leachate and the ground, involving soil chemistry, surface physics and other processes which on balance tend to reduce the potency of the material. If the leak can be sealed, then the hydraulic pressure driving the slug through the ground will be reduced, and progress downward will be slow. Given greater-than-minimum depth to groundwater, tight soils, and prompt reactions, the eventual damage to the groundwater can be minimized. In a worst case scenario, however, there will be appreciable contamination.

It is at this stage that monitoring wells really begin to earn their keep. From these wells, measurements can be made of the direction and flow rate of the contaminated groundwater, as well as of the degree of dispersion and dilution, and future patterns can be predicted. It is possible, despite all action up to this point, that the concentration will be of a level sufficient to be of concern to human health. This means developing alternate sources of water for any homes or communities that are at present drawing on groundwater from this section of aquifer. In practice, the provision of alternate supplies is some-

Figure 4: An acceptable wetland site.
Figure 5: The ideal landfill.





thing that could be considered during the construction stage, and might well be required as part of the development of the landfill.

Site Selection by the States

Although it is possible to maintain the integrity of a secure landfill over a long period of time, as outlined above, a very basic problem remains. People do not want even "the best" of hazardous-waste landfills in their vicinity. But wastes continue to be produced, and state governments may have to get involved in the task of deciding on site locations. Although this role is not one that most states would relish, it may be necessary. Serious good-faith efforts by the private sector may be unable to come to terms with local objections.

One possible strategy for siting will be outlined here. It is only one of many that are possible, it may not be the best, but it is an attempt to deal with the practical realities in an even-handed manner. At the least, it may provide a basis for reasoned discussion of the issues involved. This strategy assumes a significant, but not necessarily dominant, state role in siting. It is also based on the (defendable) premise that the problem of siting is an urgent one.

In an ideal world, one would look for the development of a comprehensive management plan, detailing the optimal number, location and types of treatment/disposal facilities. However, given the dynamic nature of the problem — with present uncertainties about the exact quantities and types of materials involved and continuing changes in costs, technical processes and other factors — such a plan may not be feasible in the short term. Nor is it presently feasible, given the states' limited resources, to carry out complete geological surveys to locate the optimal sites.

Each state must nevertheless make a first choice based on present generation and disposal patterns, and on factors such as land-use, transportation, and so on. But the onus should be on local industries to justify the "demand" — to produce the figures which demonstrate the need for particular facilities — and this will require much more involvement on their part than has been apparent up until now. A particular problem is that many of these industries, for example in the electroplating sector, are small and generally do not have the time or the expertise to become involved. But groups of smaller industries might well be represented by their corresponding trade associations.

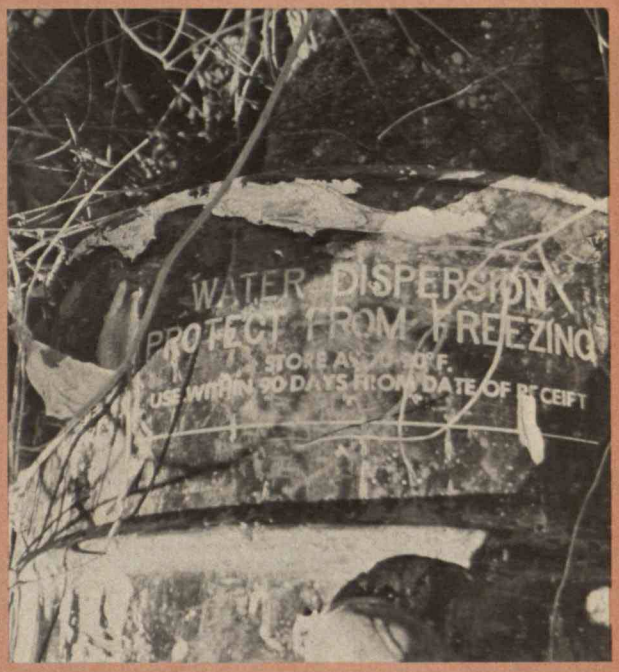
One option to be considered at the "first-stage" choice is that of establishing categories for wastes. Such classification, although not currently favored by the E.P.A., might be based on some system of ranking hazards. Under the proposed federal regulations, for example, pesticide wastes are regarded in exactly the same light as waste motor oil. As an alternative to such a blanket approach, classification

might be made according to physical state, chemical properties, or perhaps the source of the waste. This approach has a number of attractive features: the formal prioritizing of certain waste problems (which would have to occur anyway — at least informally — because of limited resources); and the potential development of different sites for different wastes (with a consequently better understanding of the problems and risks involved at each site). Such a policy could have other advantages as well: a simplification in transportation problems; and a lessening of the burden placed on any one community.

Two very important sets of data are required. The first comprises the detailed criteria to be used in examining potential sites. It is relatively simple to list such factors — hydrogeology, location, transportation impact, wildlife, local economics, etc. — but it is a lot more difficult (although not impossible) to determine how all these should be measured and interrelated in a manner that is generally regarded as reasonable. There is no suggestion here that *formal* trade-offs be developed between the different factors; such techniques are rarely acceptable to the public, and with good reason. At this point, the objective is simply to ensure that all the important factors in a siting decision have been considered.

The second need is for acceptable methods of identifying candidate sites. One obvious approach (which has begun to be used in Massachusetts, for example) is a review of existing or proposed landfills to find those which might be upgraded to R.C.R.A. standards. Another source of information on possible sites should be the waste-generating industries themselves, who can be expected to have a good knowledge of local conditions and potential opportunities, or who may have disposal areas on their own property which might be considered for development. Thus far, however, little help on these points have been forthcoming from the majority of industries, and there is an obvious need to develop further cooperation. Other approaches to finding first-stage candidate sites should include review of available geological information (although this is a really long-term task if the review is to be comprehensive), and should include an examination of federal- and state-owned lands. Since it will be generally impossible to examine all potential locations within a reasonable time, the considered sites should at least represent a fair cross-section.

While the site-search process is underway, it will be necessary to decide on how facilities will be operated (although the common assumption, at least in



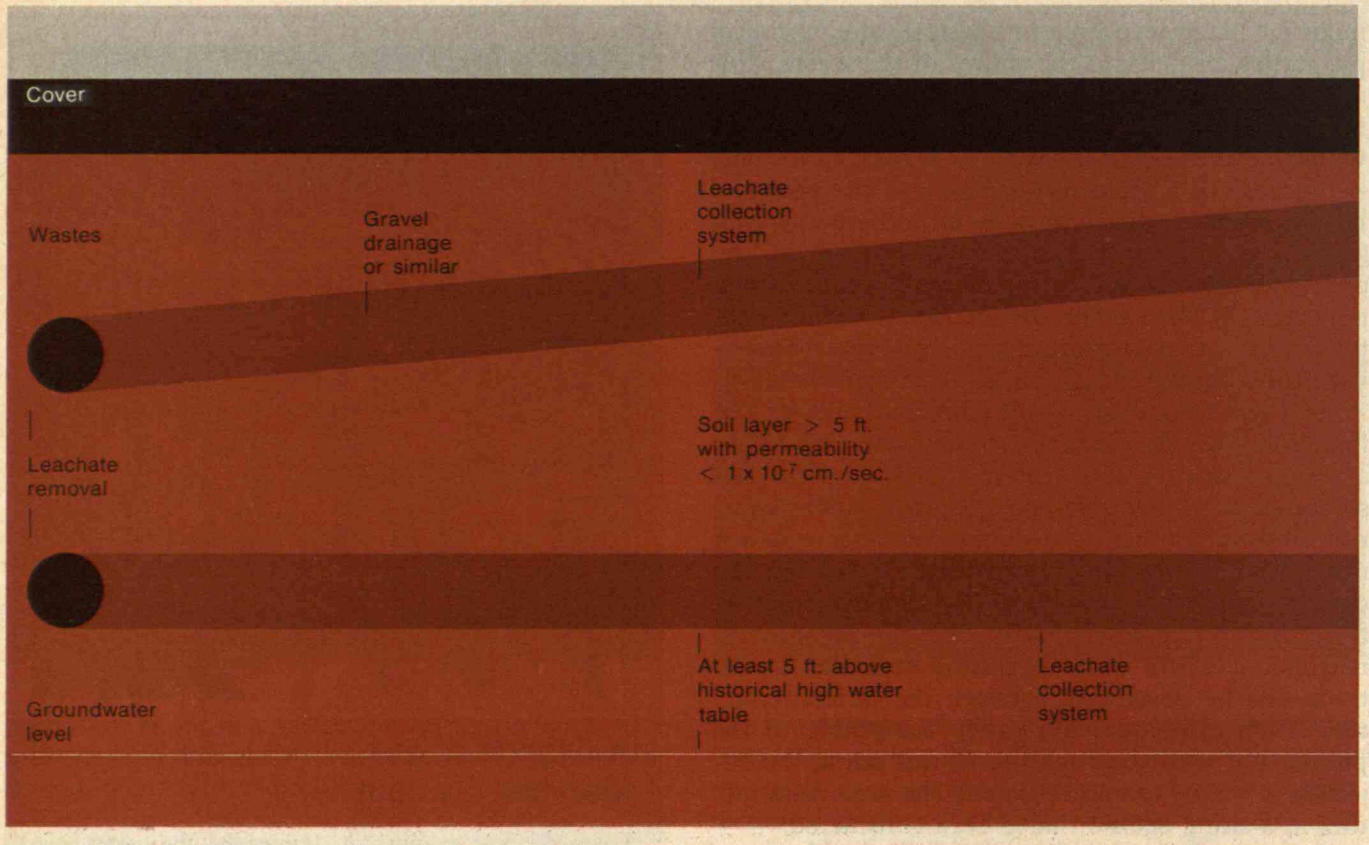
A Glance at the Manifest System

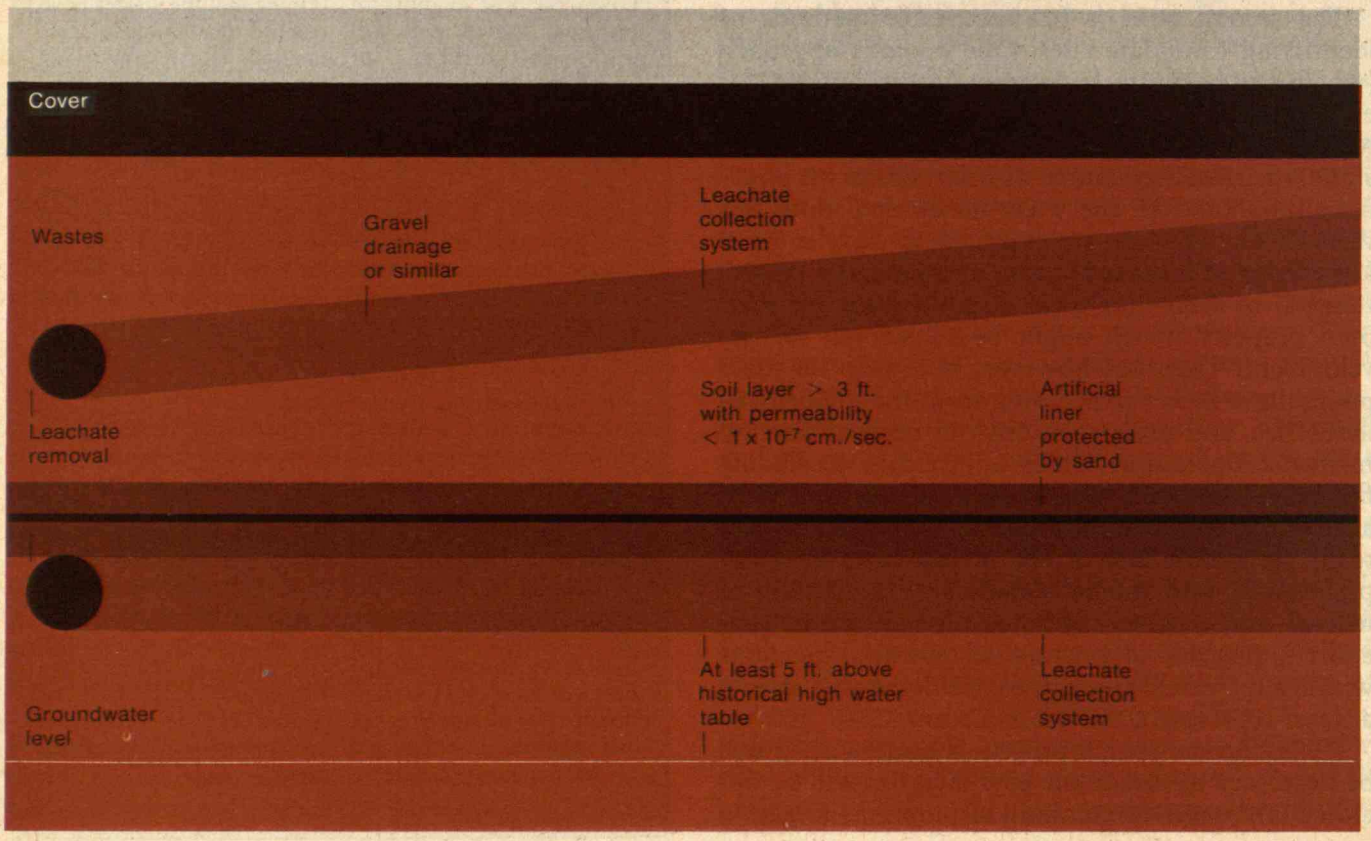
Given the vast quantity of material which will fall under the authority of R.C.R.A., some form of accounting is necessary to keep track of the wastes. One of the keystones of R.C.R.A. is the "cradle to grave" system which makes the generator responsible for the safe disposal of his wastes.

Under the proposed regulations, a waste generator who sends his waste to an off-site disposer must retain one copy of a manifest, which lists in specified detail the wastes in the shipment and the licensed facility to which they are to be delivered. The handler takes as shipping document the original manifest and copies. When the shipment is delivered, the disposal facility operator must sign the manifest to acknowledge receipt and must return the original to the generator, thus confirming that the wastes have reached their proposed destination. If the original of the manifest is not returned to the generator within 30 days, the E.P.A. must be informed. In addition, the generator must retain copies of all manifests for several years and must submit annual reports to the E.P.A. The burden of monitoring the movement of any hazardous waste is therefore placed on the generator.

The administrative costs associated with proper testing, labeling, and recordkeeping, as well as preparing and checking the manifests, are expected to be high. A recent study (prepared for the E.P.A.) estimates average administrative costs as adding, at a minimum, half again as much as the technical treatment and disposal costs. — *D.H.* □

Two liner designs for landfills, as suggested by the U.S. Environmental Protection Agency, to achieve containment.





New England, is that facilities are best run by a private disposal firm under some form of contract with the state); and also to establish the necessary organizations for long-term monitoring and surveillance.

The final decisions — exactly which sites to develop and in what manner — will essentially be political ones. This implies a fundamental need for public participation, right from the beginning, to achieve better designs and easier acceptance of facilities.

Future Prospects

The question of "Just how much disposal capacity is required?" raises a complementary question: "To what extent can the quantities of waste be reduced?" There is always a certain amount of recovery and recycling being performed, but some stimulus is necessary before these practices begin to have a significant impact on waste quantities. Assuming adequate responses to the technical, economic and environmental problems associated with land disposal, it is clear that disposal costs will increase, and this should provoke increasing interest in waste reduction. In addition, the rising prices of raw materials will make waste doubly costly, and a long-run shift to less wasteful production can be expected. In the near future, therefore, some progress can be expected in reduction of waste quantities; but rapid changes are unlikely. This is because those alterations which are most simply made, such as cutbacks in water use to reduce waste volume, have in many cases already been instituted. Thus, future changes in already-operating plants will be more difficult and less rewarding. (In the same light, the concept of waste exchanges — where one firm's waste becomes another's feedstock — is an intriguing one, but the actual reduction in overall volume that can be achieved in this way is relatively small. The really "good" wastes are already being used.)

In practical terms there will be a great deal of variation in the responses of different firms to the increasing economic pressures. This variation will depend on factors such as the processes used and the size and organization of firms. Some of the largest chemical firms have accepted growing environmental regulation as a stimulus to become involved in questions of materials conservation rather than simply as counter-productive measures to be avoided (one of the better known being the "Pollution Prevention Pays" program at the 3M Company). In any case, this is another aspect of the hazardous waste problem where increased industry/government cooperation in the development of management alternatives may be the key to successful solution.

It is important to note that R.C.R.A. regulations will not cause a flood of new hazardous materials into the environment. On the contrary, they mark the beginning of a serious nationwide drive to control wastes which are at present being dumped, often in a reckless manner. Certain actions, especially those aimed at preventing gross contamination of groundwater, need to be taken at once. But the process of "cleaning up" will not be completed quickly, and the *best* solutions — the complete removal of potentially hazardous materials from the waste streams by means of "materials-flow" concepts — will take a long time to implement. It is worth the time and the effort, however. Careful design of industrial processes can yield big dividends not only in the reduction of hazardous waste disposal problems, but in materials and energy efficiency as well.

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There are no books available which give a good overall treatment of this relatively new topic. There are many reports, however, available through the E.P.A., on technical aspects of the problem and on the situation in different industries. Much of this is summarized in the more than twenty background documents supporting the presently proposed R.C.R.A. Subtitle C regulations.

Two other reports, specifically related to the situation in Massachusetts, are:

GCA Corporation, *The Generation and Disposal of Hazardous Waste in Massachusetts*, Oct. 1976. Bedford, Mass.

M.I.T. Civil Engineering Department, Water Resources and Environmental Divisions, *Development of a Comprehensive Plan for the Management of Special and Hazardous Waste in Massachusetts*, July 1979.

There are a number of interesting articles that have appeared recently. A sample of these would include:

"E.P.A.'s Hazardous Waste Program: Will it Save our Groundwater?" by Gene Dollaire in *Civil Engineering*, Dec. 1978.

"Recyling Hazardous Wastes" by Carl A. Schwarzer in *Environmental Science and Technology*, Vol. 14 No. 2, Feb. 1979.

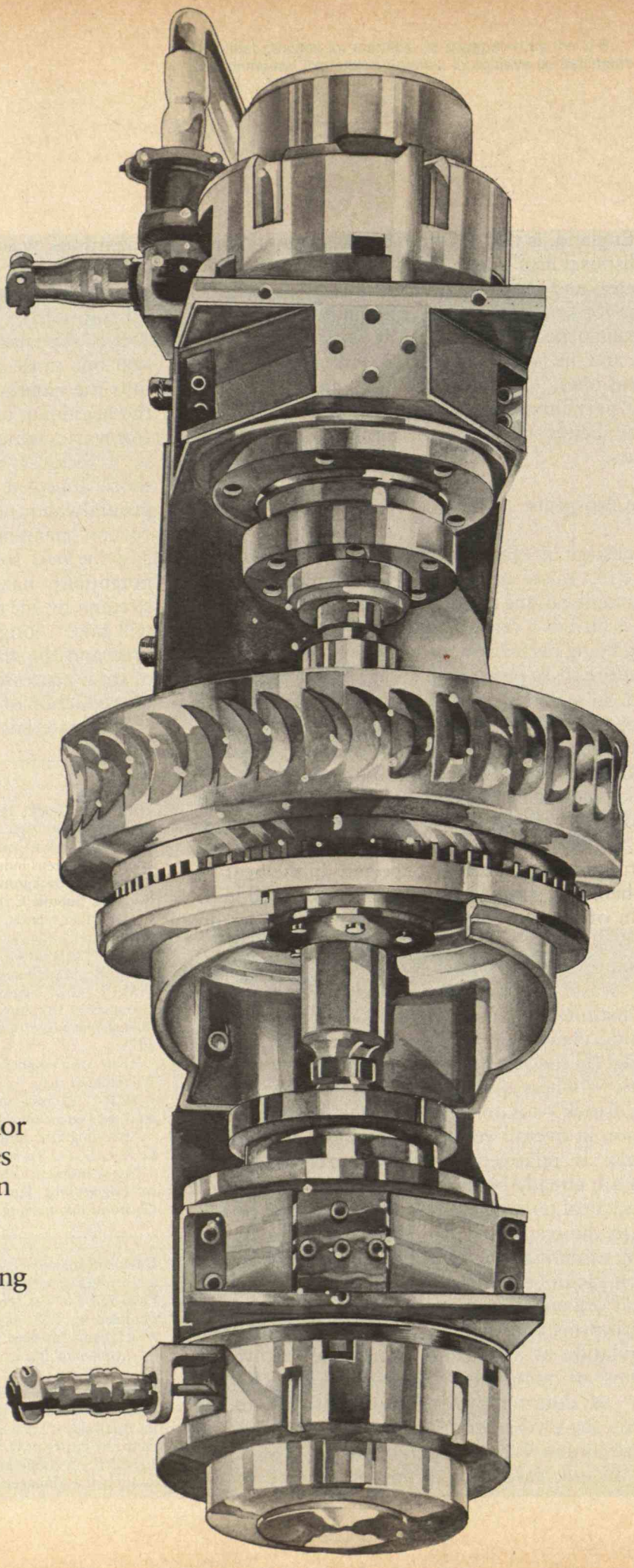
"How Industry Can Prepare for RCRA" by Richard Sobel in *Chemical Engineering*, Jan. 29, 1979. This is part of a very good series in *Chemical Engineering* on technical aspects of waste disposal.

David Hanrahan, a civil engineer, was educated in Ireland. He has been a resources development consultant both in England and in the Middle East, and is a Chartered Engineer in the United Kingdom. He recently obtained an S.M. degree in the Technology and Policy Program at M.I.T., and has been working with the Massachusetts Department of Environmental Management.

Many of the ideas presented in this article were derived from a research project supported by the Ford Foundation (through its program in Policy Analysis for State Environmental Management). The project was directed by Professor D. H. Marks of the Department of Civil Engineering at M.I.T., in cooperation with the Massachusetts Department of Environmental Management (under Commissioner Richard E. Kendall).

Flywheels For Energy Storage

by Alan R. Millner



Flywheels may be economically superior to chemical batteries for storing energy in solar- and wind-power systems and for peak load shaving on electric utility systems.

Electrical loads generally do not demand power at the same rate as it is available. Typical power demand follows a cyclic pattern with large peaks on weekday evenings. The power available from renewable energy sources such as the sun or wind also have cyclic patterns — but they do not peak on weekday evenings. Peak power needs can be met by building oversized sources whose full capacity would be unused during off-peak periods; the oversized facilities are therefore uneconomical. A better answer is a means of storing energy generated when demand is low until demand is high. Several storage methods are familiar, at least in concept; for example, pumped-storage facilities in which water is pumped into a high reservoir when surplus power is available and then released to turn a turbine at times of peak load. A flywheel is another example — a massive wheel whose rotation — and energy — is built up at times of low power demand and drawn down by peak-power loads.

Flywheels for Load-Leveling

Flywheels appear to be the ideal energy storage element in solar electric or wind power systems. They can smooth the load on the generators by providing the energy to generate electricity when the sun is not shining or the wind is not blowing; and they can also provide peak power to an electrical load during periods when demand exceeds supply, such as during motor start-ups. Indeed, once spinning, flywheels can deliver energy rapidly for transient load conditions, which makes them especially useful in industrial and agricultural applications.

Applications without utility grid connections form a very small part of U.S. energy demand, but they are important for the following reasons:

☐ The developing nations represent a large market that cannot afford to build utility grids and so look to alternative, dispersed energy sources for electrical power.

☐ The foreign and domestic stand-alone, non-grid, energy system market may provide a vital economic lever to move solar or wind power technologies into a production scale that is economically feasible for the major, utility grid sector of the U.S. energy economy.

All of these applications are stationary, so the flywheel need not be moved around (as in vehicles), avoiding potentially high dynamic forces on bearings and mounts. With mobility eliminated as a design factor, flywheels need not be lightweight or small, and they can be made of relatively cheap materials. Moreover, a flywheel energy-storage system can be placed anywhere, without serious environmental effects or special geographic requirements, unlike alternatives such as pumped hydro or chemical storage.

Improved Flywheel Materials

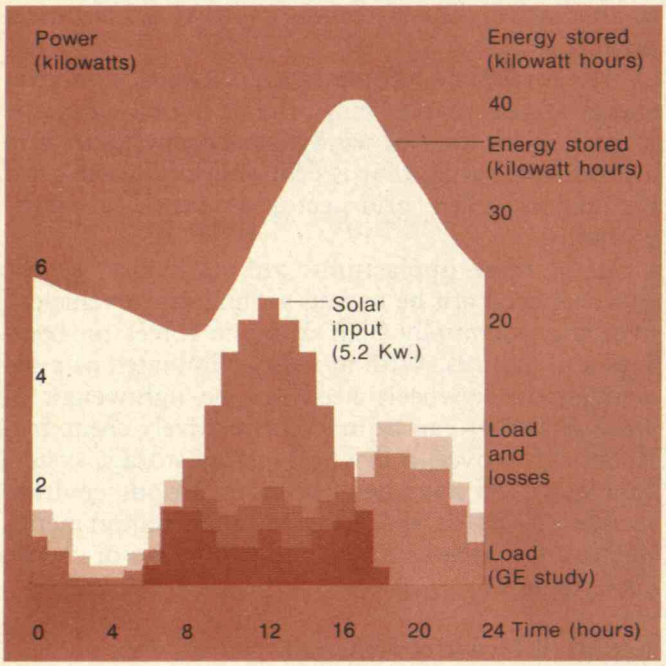
The strength of a flywheel determines its usable stress — the amount of kinetic energy it can store before it will break. The cost of storage, say per kilowatt-hour, is proportional to the strength-to-weight ratio of the material and its cost per pound. High strength per unit weight is important only in weight-limited applications, such as vehicles; for low-cost stationary systems, expensive materials such as titanium, steel, and aluminum, from which flywheel rotors traditionally have been made, are precluded. Rotors made of these metals cost over $200 per kilowatt-hour stored.

What happens when flywheels fail at high speeds? Solid metal rotors can be quite dangerous if they suddenly break into large, heavy, high-velocity fragments with lots of penetrating power. But for safety they can be installed in pits in the ground, an inexpensive and simple recourse.

A number of less expensive, anisotropic materials — with strength mainly in only one direction — can actually outperform solid steel as a rotor material. Examples: steel wire, such as tire or hose wire, glass fiber (which must be coated to avoid abrasion under

Aerospace magnetic bearing test model. The two magnetic bearings, at the ends of the shaft, draw only a few milliamperes of current.

Illustration: Roger Leyonmark



Typical daily energy balance envisioned for a residence using and storing electricity generated from solar photovoltaic cells. Assumptions: total daily solar input is 38 kilowatt-hours; total daily load is 26.7 kilowatt-hours, and efficiency of system is 70 per cent.

cyclic stress), and a new thin amorphous metal ribbon, which has high usable stress. All of these can be wound in a "bare-filament" flywheel, which looks much like a spool of yarn. Alternatively, the filaments can be embedded in a matrix of weaker, glue-like material to produce a composite. The presence of such a matrix permits machining and balancing of the rotor but takes a significant toll in energy storage per pound — and per dollar.

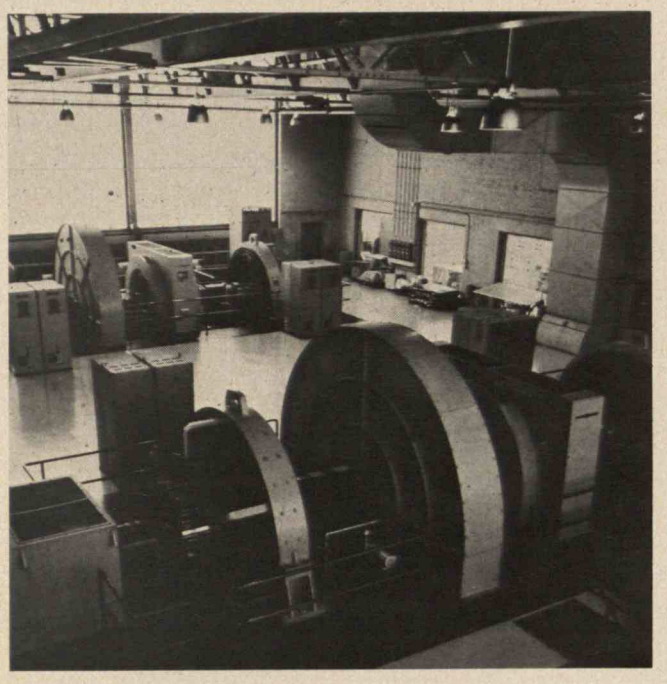
Anisotropic rotors, especially in bare-filament design, have a comparatively benign failure pattern. They tend to separate into many small threads and coils, dissipating much of their energy in the process and unravelling gradually. The resulting fragments look like soft cotton or fiberglass insulation material. They are small, have a fraction of the penetrating power of the same size metal rotor fragment, and are more easily contained inside the flywheel system.

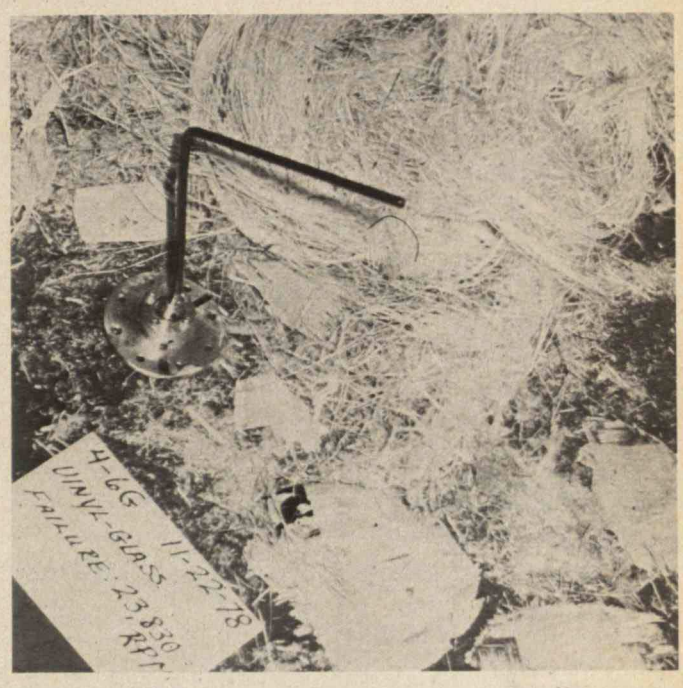
High-performance composite materials, such as graphite-epoxy or Kevlar, perform remarkably well in flywheel rotors but are too expensive at present for use in stationary locations. Their high strength-to-weight ratio may justify their use in automobiles and spacecraft despite the high cost.

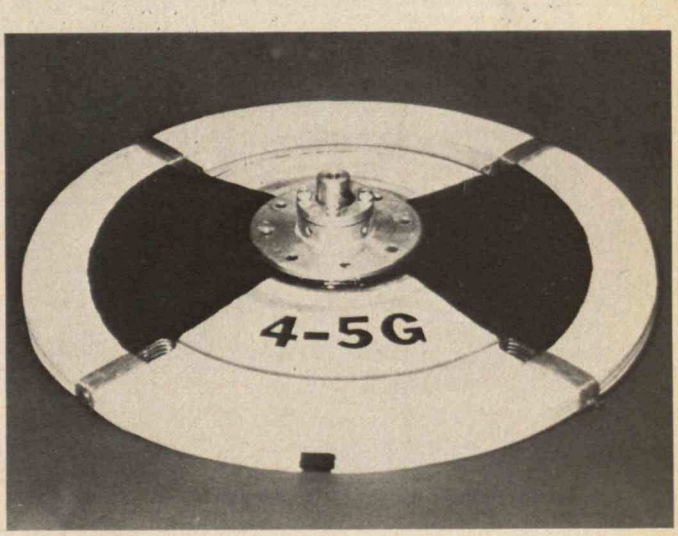
How Big?

To get a sense of the size of a practical rotor, let us suppose a solar- or wind-powered house uses 25 kilowatt-hours of electrical energy per day and requires one day's energy storage. Assuming reasonable efficiency of generation and depth of discharge, a storage element would have to be capable of handling 40 kilowatt-hours. Thus, assuming a material that can store 10 to 20 watt-hours per pound, we require a rotor weighing one to two tons; this might be about three or four feet in diameter and three feet thick — a size that compares favorably with batteries of similar capacity.

A rotor for a larger installation, such as an apartment building, school, or shopping center, might be ten times heavier and have dimensions on the order of six feet. For a utility system substation with storage an order of magnitude larger, the rotor would weigh up to 20 tons and be 12 feet in diameter.







Top left: A large flywheel assembly used to buffer electromagnetic loads at the Francis Bitter Magnet Laboratory (Photo: M.I.T.);

Bottom: Low-cost bare filament flywheel rotor. Such units can store energy at less than $50 per kilowatt-hour. *(Photo: D. Rabenhorst,* Johns Hopkins Applied Physics Laboratory);

Top right: Bare-filament flywheel rotor after failure at high speed (*Photo: D. Rabenhorst*)

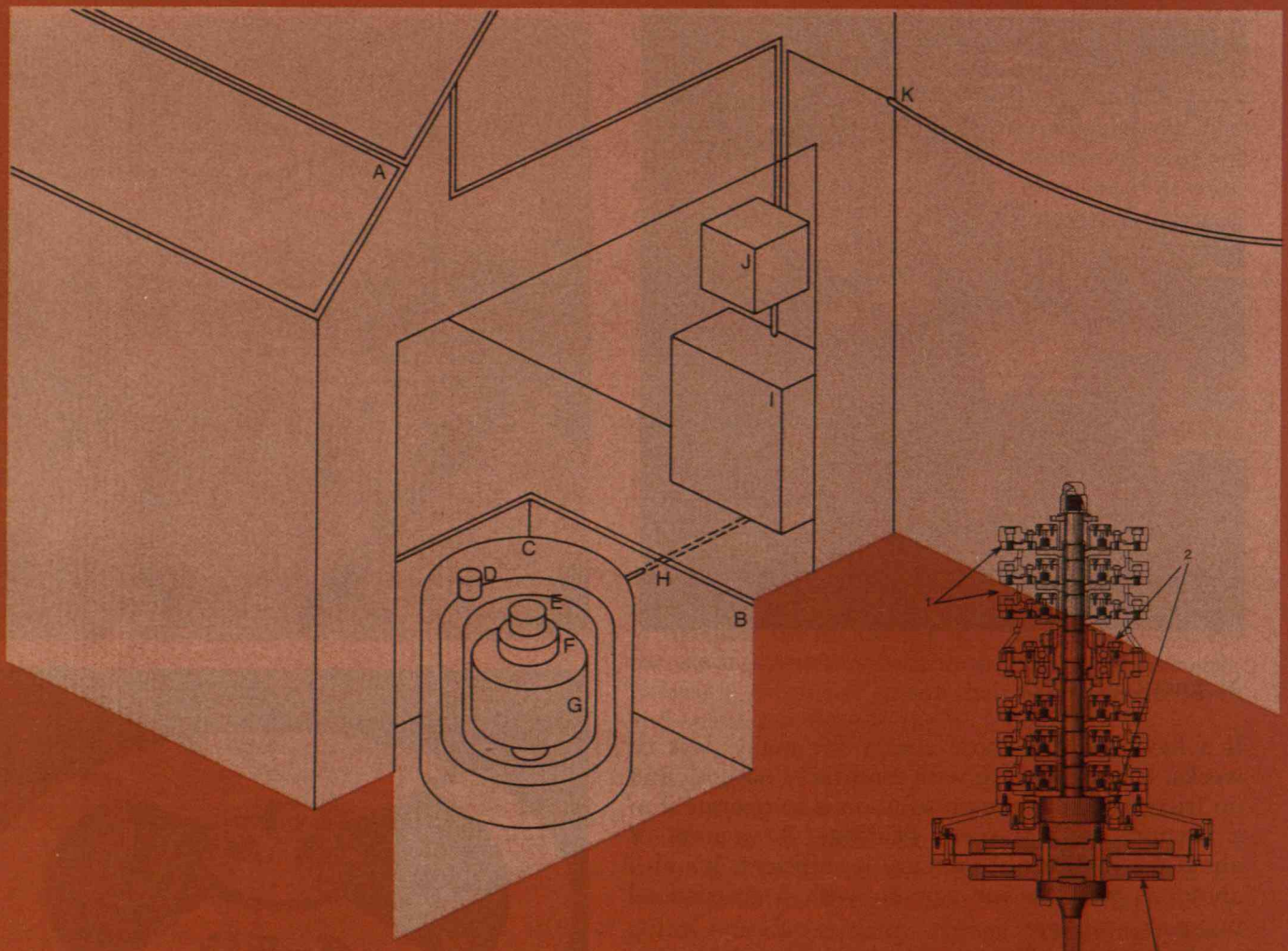
Magnetic Bearings

If a flywheel is to store energy for many days or weeks, it must revolve with essentially no drag and no friction. The common solution is to operate it in a vacuum on high-speed bearings. A vacuum of about ten microns of mercury is sufficient. It's also about as well as one can do with a mechanical pump.

The bearings have no small task. They must support for many years the weight of the spinning rotor — typical weights and speeds for a residential model are one to two tons and 10,000 to 15,000 revolutions per minute — as well as handle any dynamic loads due to imbalance.

Ball, roller, and needle bearings are not the answer; they do not lubricate easily in a vacuum, and their lifetime at high speeds is a limited, statistical matter. Also, their drag under high loads is often in excess of what can be allowed in these storage systems. Magnets could be used to remove the static load from such mechanical bearings, but ideally a totally magnetic suspension could be used to com-

Above: A flywheel-based system for storing energy in a private residence. The one- to two-ton flywheel would spin to fifteen thousand revolutions per minute in a ten-micron vacuum chamber. Cost is competitive with — and likely less than — that of a battery-based system of similar capacity *(See chart on p. 38).*
Below: Diagrammatic view of a residential flywheel unit under development at M.I.T. Lincoln Laboratory. Note the six magnetic bearings, whose stators are fixed to a support frame and whose rotors are fixed to the flywheel shaft. A mechanical bearing provides support if magnetic bearings are not acting. The ironless stator of the motor-generator is also fixed to the support frame; it is sandwiched by rotors containing permanent magnets. The flywheel rotor — at the bottom of the shaft — is still under development.



A Solar cell modules
B Approximately 5 ft. diameter pit
C Trap door
D Vacuum access
E Top bearing
F Motor/generator
G Rotor
H Connecting underground conduit
I Electronics
J Junction box
K From utility

1 Magnetic bearing (6 elements)
2 Touchdown bearings (2 elements)
3 Motor/generator assembly
4 Rotor

pletely preclude physical contact between rotor and stator.

Magnetic bearings have been developed for aerospace applications, but only recently has their practicality been demonstrated as the heart of energy storage systems. The breakthrough is partly due to the recent development of stronger permanent magnets, such as those made from rare-earth cobalt compounds. Only ten pounds of such magnets could support two tons of rotor. Although the free suspension of a weight with permanent magnets is an unstable condition, an electromagnet servo loop has been used successfully to stabilize the rotor position.

Magnetic bearings should last a long time in flywheel energy-storage systems. Measurements of the performance of such bearings demonstrate that in a good vacuum they will support required weights with minimal drag for 20 to 30 years at least. Moreover, this lifetime is not limited by loading or shaft speed.

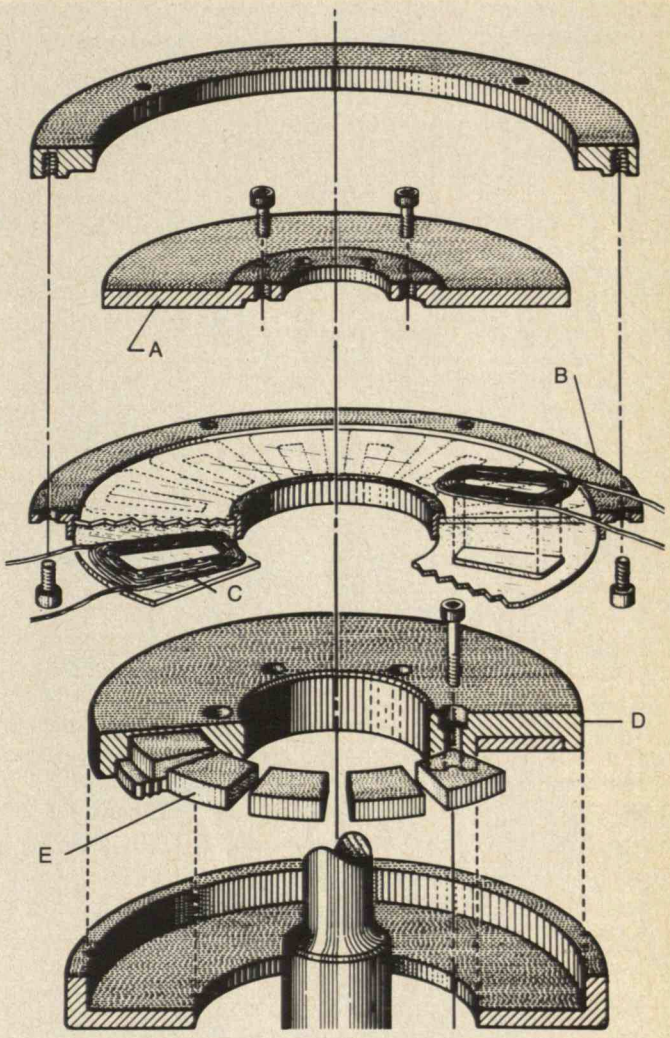
Inputs and Outputs

Once a flywheel rotor is suspended and able to spin, to be useful it must become part of an energy storage system that converts electrical energy to kinetic energy, stores it, and reconverts it into electricity, passing it to the load as required.

The conversion of energy from electrical to kinetic form and back again is done by a motor-generator unit. Most conventional motor-generators use brushes or slip rings to transmit current between stator and rotor. But brushes do not hold up well in vacuum at high speeds.

One way to solve the problem is to bring the rotor shaft through a seal in the wall of the rotor's vacuum chamber and to place the motor-generator unit itself in the air. Unfortunately, this method creates problems in motor windage, seal drag, seal leakage, and life.

A better answer is to use a brushless motor-generator inside the vacuum chamber. Such a unit has a rotating magnetic field that reacts against stationary armature wiring to produce torque. The rotating field can be produced in smaller flywheel



A Rotor steel plate
B Ironless stator
C Coils
D Rotor permanent magnet assembly
E Magnets

A motor-generator being designed at M.I.T. Lincoln Laboratory. As the rotors spin with the flywheel, a collection of electronic switches (not in figure) called a cycloconverter changes the electrical output from the ironless stator into a close approximation of ordinary 60-cycle alternating current.

A comparison of costs for residential electrical storage systems, batteries vs. flywheels. Residential demand was set at 25 kilowatt-hours per day, with peak power levels set at 8 kilowatts of direct current and 10 kilowatts of alternating current. Batteries were discounted at a 10 per cent rate, and inflation was set at 6.5 per cent.

Deep-discharge batteries, with a nominal five-year life, cost about $100 to $140 per kilowatt-hour capacity today. Inverters in the 10-kilowatt range cost from $500 to $1,000 per kilowatt of alternating current output.

The shelter for a battery installation must be fireproof, heated, and equipped with a blow-out wall, hydrogen vent tubing, and necessary wiring. The flywheel shelter need provide only the required volume for the vacuum chamber and wiring.

The maximum power tracker system is not presently available in production quantities.

Today's Technology			**1985 Technology**		
	Unit price (1980$)	Residence price (1980$)		Estimated unit price in 1985 (1980$)	Residence price (1980$)
Battery system					
Batteries: four sets each with 5-year life	175 per kw/hr	12,600	Batteries: three sets each with 7-year life	42 — 70 per kw/hr	2,523 — 4,200
Inverter	280 per kw AC	2,800	Inverter	70 — 420 per kw AC	700 — 4,200
Max power tracker	150 per kw DC	1,120	Max power tracker	70 — 210 per kw DC	560 — 1,680
Enclosure	85 per kw/hr	2,100	Enclosure and installation	70 — 84 per kw/hr	1,750 — 2,100
20-year Totals		$18,620			$5,533 — 12,180
Flywheel system					
Rotor	280 per kw/hr	7,000	Rotor	70 — 140 per kw/hr	1,750 — 3,500
Motor-generator	162 per kw AC	1,630	Motor-generator	105 — 140 per kw AC	1,050 — 1,400
Magnetic bearings	105 per kw/hr	2,618	Magnetic bearings	14 — 28 per kw/hr	350 — 700
Vacuum housing	60 per kw/hr	1,512	Vacuum housing	35 — 56 per kw/hr	875 — 1,400
Shaft and hub	34 per kw/hr	840			
Electronics (motor)	140 per kw DC	1,120	Electronics (motor)	42 — 105 per kw DC	336 — 840
Electronics (generator)	140 per kw AC	1,400	Electronics (generator)	42 — 140 per kw AC	420 — 1,400
Enclosure	45 per kw/hr	1,120	Enclosure	34 — 45 per kw/hr	840 — 1,120
Totals (Minimal 20-year life)		$12,314			$5,621 — 10,360

units by spinning permanent magnets and in larger units by inducing rotating fields by use of stationary coils. Such motors, which require electronic commutators, have been used for many years in high-performance systems.

A number of existing designs have potential applications as flywheel energy input-output devices: ironless armature permanent magnet motors, Lundell or Nadyne (induced field) motors, and perhaps induction motors. The power electronics required for commutation of these motors varies with the motor type. The lowest cost motor (induction) requires the most expensive electronics, and the cheapest electronics go with the most expensive (permanent magnet) motor. It appears that total system costs are minimized with the permanent magnet motor for small, house-sized, systems, but the question is yet to be resolved for larger ones.

Stand-alone electrical inputs can vary widely according to their source, complicating the job of any conversion-storage scheme. For example, solar cell systems have a DC electrical output and wind systems often have a low-frequency AC electrical output, while loads usually require regulated 60-hertz AC electrical power.

Driving a DC motor with an AC input is a standard and well-understood process, but the generation of regulated 60-hertz AC power from a flywheel generator's variable-frequency, variable-voltage output is new. If a flywheel motor-generator's output is rectified to make DC, then standard inverters can be used to produce AC for the load, but such equipment is expensive and sometimes inefficient.

An interesting approach is to use a special circuit called a *cycloconverter* to do the entire job. A cycloconverter is a group of electronic switches that are placed between the flywheel output phases and the load. By closing different switches at different times, a "chopped up" version of the flywheel motor-generator's high frequency output can be used to approximate the desired output voltage. This technique turns out to be relatively inexpensive and efficient, but the system still needs to be evaluated in practice to see how well it fits this application.

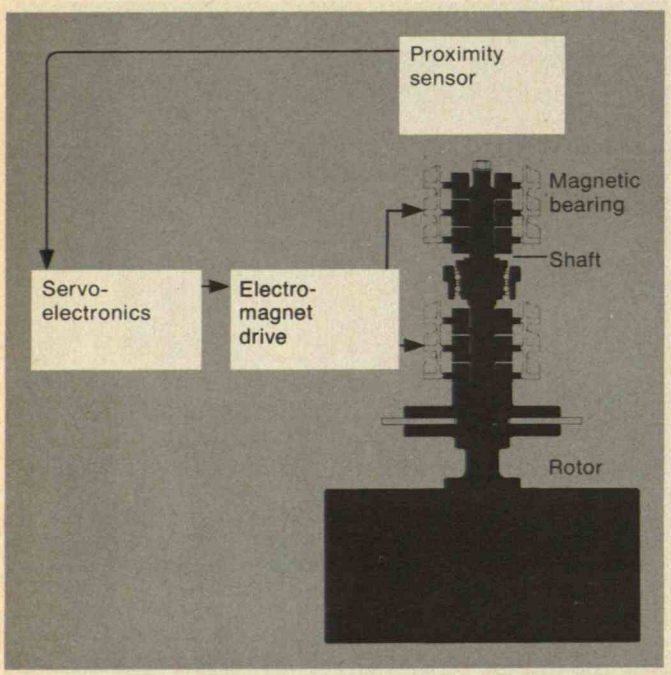
Flywheel system efficiencies (per cent)		Battery systems efficiencies (per cent)	
DC motor electronics	92	Batteries	80
DC motor	96	Inverters	85
AC generator	95	Max power tracker	96
Drag	95		
Generator electronics	92		
Overall efficiency	73.3		65.3

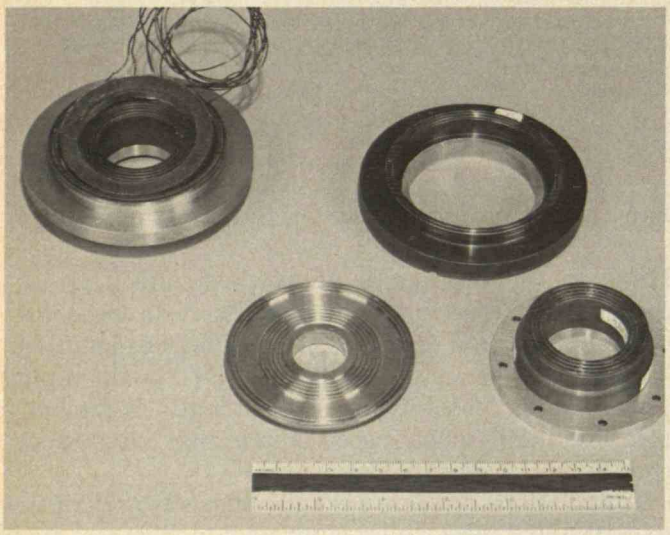
Comparison of efficiencies: flywheel vs. battery systems. Note that the flywheel system is more efficient — and also avoids the periodic replacement of batteries.

How Much Would a Flywheel System Cost?

How do the economics of flywheels stack up to those of batteries on a 20-year-life-cycle basis for typical household demand, say a storage capacity of 25 kilowatt-hours, 6.0-kilowatt DC peak input power, and a 10-kilowatt AC peak load? At the bottom line the flywheel-based system may be cheaper than batteries of equal capacity.

Calculations indicate a range of costs from $5,600 to $10,400 (1980 dollars) for such a flywheel system. An advanced battery-based system would cost from $5,500 to $12,200 including the cost of two battery replacements, consistent with their assumed seven-year useful life and the 20-year system life requirement.





Above: Schematic drawing of electromagnetic loop used to stabilize a rotor suspended on magnetic bearings. A sensor tells electronic controls how to vary the current in the electromagnet drive that activates the bearings to maintain the proper gap between rotor and stator. (*From a drawing by A. Millner*)
Below: Magnetic bearing parts. Clockwise, from top right: outer stator subassembly, inner stator subassembly, rotor, and complete stator with control coil and power leads in place. (*Photo: M.I.T. Lincoln Laboratory*)

An additional correction in these figures must be made because of the different efficiencies of the two systems: 73 per cent for the flywheel-based system and 65 per cent for the battery-based system. The cost of additional solar array or larger windmill unit required should be added to the battery-system cost to allow a truly meaningful evaluation.

Another enlightening comparison can be made between the two systems by assuming 1979 technology, but production quantities for all components. Typical single-residence application of a flywheel system would be $17,240; for the battery system, $18,620.

The conclusion is apparent. Flywheels could be cost-competitive with batteries today.

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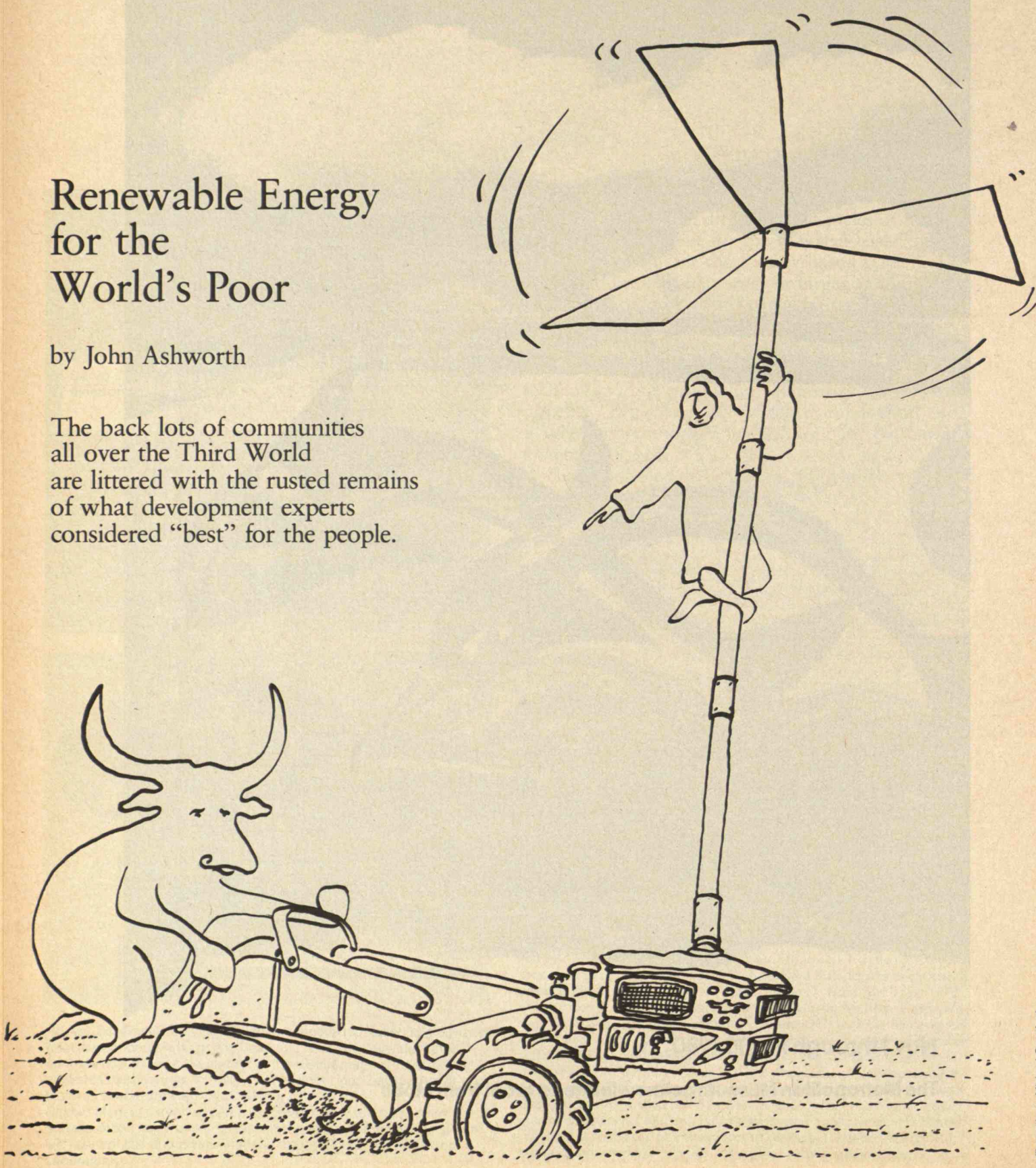
Alan R. Millner has been a staff member of the M.I.T. Lincoln Laboratory since 1972. He received his S.B., S.M., and E.E. degrees in electrical engineering from M.I.T. in 1970 and his Sc.D. from M.I.T. in 1972. During that period, he was employed at the Martin Marietta Corp. and the U.S. Naval Ordnance Laboratory. From 1972 to 1976 he designed power and electro-optical components and systems for communications satellites *LES-8* and *LES-9* and engineered the operations center for these spacecraft. From 1976 to 1977 he designed and developed a prototype spacecraft energy and momentum storage wheel unit with magnetic bearings. Since 1978 he has designed solar photovoltaic power system components and systems for terrestrial applications. He is now principal investigator of a task force to develop a flywheel energy storage and conversion system for solar photovoltaic applications.

Renewable Energy for the World's Poor

by John Ashworth

The back lots of communities all over the Third World are littered with the rusted remains of what development experts considered "best" for the people.



There is a quiet revolution taking place in the poor rural areas throughout the Third World. Primitive biogas generators, highly sophisticated photovoltaic cell arrays, wind generators, small-scale hydroelectric generators, and flat-plate solar collectors are being erected in areas that have never seen energy sources other than human and animal labor, firewood, and dung. Plans are being completed for whole new communities powered by sources that would have been considered exotic only a few years ago: photovoltaic cells; "solar" ponds; agricultural refuse; and fast-growing trees cultivated on special "energy plantations", for example.

In virtually every case, the introduction and development of these technologies has been stimulated by non-commercial organizations from outside the village and often from outside the country. Although centralized electrical power still dominates the energy spending of Third World nations and the energy-related lending of major international agencies, the provision of decentralized rural energy systems has become a major focus of controversy within the development community. The cost of energy and the "appropriateness" of conventional Western energy technologies have emerged as critical issues in this debate.

Unlike their counterparts in the urban areas of both the industrial and developing worlds, the rural poor in Third World countries use energy almost exclusively for the most basic human needs: food, potable water, shelter, clothing, space heating and sanitation. Moreover, they generally do not have enough energy available to meet even these needs adequately. It is estimated that the per capita consumption of energy in India is less than 1/30th that of the United States, while in the farm sectors of the two countries the ratio is even greater — 1 to 50. And India is by no means an extreme case in the developing world, since it has a substantial industrial sector and large domestic supplies of fossil fuel.

The actual amount of energy required to support human life and basic subsistence agriculture is a matter of much speculation but little field measurement. What is important, however, is not any exact minimum energy requirement but that for large portions of the world's rural poor the demand for energy is virtually irreducible and relatively insensitive to price changes. Rising prices of one fuel may induce substitution of another, but food still has to be cooked, soil must be tilled, and the harvested grain must be threshed and ground. Of course, cheap energy would be especially welcome, and would allow for an increase in food consumption, help ensure freedom from disease, provide contact with the outside world, and allow some lessening of the worst physical drudgery, as, for example, in agricultural labor.

The Need for New Energy Sources

Developing nations face a number of obstacles to rapid economic growth: stable or declining agricultural productivity; soil depletion; deforestation; balance of payments deficits; low utilization of fertilizer; and large crop losses due to spoilage. Energy — its form, its cost, and the unintended side-effects of its production and consumption — is the common link among all these problems.

Traditional fuels (e.g., firewood and dung) are far more important sources of energy in the developing world than "conventional" fuels, accounting for an annual average of 25 million B.t.u.s per capita versus 10 million B.t.u.s per capita for commercial fuels. But conventional fuel consumption, mostly of petroleum, began accelerating in the last decade. The rate of non-O.P.E.C. commercial fuel consumption in the Third World rose a remarkable 250 per cent between 1970 and 1974.

But since 1973, when the rapid expansion of oil consumption had been well underway, the world price of petroleum has risen more than 700 per cent. This oil price surge, combined with high prices for industrial goods and slumping price levels for other commodities, has led to major balance of payments problems for most of the Third World nations (since few of the poorest developing nations produce significant amounts of fossil fuels).

To meet the oil price escalation, the more advanced developing nations turned to large commercial banks for credit, while they redoubled efforts to develop conventional domestic energy sources. Between 1972 and 1976, the total external debt of

Mexico, Brazil, and Korea jumped from 18.2 billion to 49.3 billion dollars, with 62 per cent of this rise coming from private financial institutions. While this massive surge in borrowing was extremely costly because of the burden of repayment and interest, these large industrialized nations were able to move swiftly toward a partial solution through the promotion of exports, austerity programs, and domestic fuel sources. Mexico and Korea have substantial domestic hydrocarbon reserves, and both are rapidly expanding production to replace imported oil. Brazil is launching an extensive oil drilling program, and is developing its large hydroelectric potential, while continuing with plans to reduce oil imports through ethanol production and biomass conversion.

The poorer nations of the developing world faced the same price rise, but they were unable to reduce oil consumption. Moreover, they lacked the capital and expertise to develop local conventional fuel sources. In most cases, these countries also lacked substantial indigenous reserves of oil or coal. The increase in energy demand had to be met by the same traditional fuels that provided energy for domestic needs for hundreds of years. But these fuels — firewood, dung, straw, and peat — were becoming more and more scarce due to over-consumption. Though some efforts have been made to increase their availability — more firewood through the development of community woodlots (in Korea), the cultivation of fast-growing plant species (in the Philippines), and the development of more efficient stoves and biogas generators, for example — such solutions have not met the increase in demand.

The poorest nations turned to the multilateral (i.e., international and collectively funded) assistance agencies and to bilateral aid programs (direct assistance from individual developed nations) for help. The foreign debt of Mali, Senegal, Bangladesh, and Nepal jumped from 1.02 billion dollars in 1972 to 4.42 billion in 1976, with much of this aid simply paying for current consumption. It did not provide for new local fuel sources to replace imported oil, nor did it allow for the growth in per capita energy use. The rapid increase in the demand for foreign assistance, and the spectre of increasing competition for limited petroleum reserves, made the development of both conventional and renewable energy sources in the Third World a major priority for the industrialized nations.

The Response of the Development Community

Until recently, the solution of the development community to all of these energy-related problems had always been the same: electric power on the model of the advanced Western nations. There was near-universal agreement that top priority should be given to the creation of large centralized hydroelectric and nuclear plants, which would provide abundant, cheap energy while reducing dependence on imported fossil fuels. In the mid-1970s a rising chorus of Third World critics dissented, saying that the energy thus provided was not cheap, that it flowed to the wealthy urban dwellers rather than to the rural poor, and that the whole strategy replaced one type of imported dependency with another. They argued further that most of the best hydroelectric sites had already been exploited, and that additional capacity would be available only from less accessible and more expensive sites.

The response of the major donor institutions to the rural energy problems, and to Third World criticism of their efforts, has been complex and fragmented. Organizations concerned with the "appropriateness" of technologies, with the redistribution of power between the developed and developing world, and with the reduction of political and economic inequality inside developing nations have quickly become strong advocates of small-scale rural energy systems. The specialized agencies of the United Nations and the development agencies of several smaller European nations fall into this category. They have begun to commit substantial portions of their resources to the development and diffusion of renewable energy sources in the Third World.

Others have taken a more cautious approach, adding renewable energy systems as experimental features of projects designed to meet other development objectives — increased agricultural production, sanitation, education, and community health

MIT

This page: Mary L. Bowden, graduate student, tries on a space suit at N.A.S.A.'s Marshall Space Flight Center in Huntsville, Ala. in preparation for experiments in their neutral buoyancy facility. Story on page A8. Photo: Michel A. Floyd, '80, courtesy *Technique*

"The Institute is very lucky to have him here," said President Jerome B. Wiesner (left) on October 5 as he introduced Paul E. Gray, '54, to the faculty as president-designate. Dr. Gray responded with his own tribute: serving as Dr. Wiesner's chancellor has been "a remarkable apprenticeship" which he would not "trade for any other experience" he can imagine. Earlier that day, in the privacy of the Corporation meeting after its unanimous vote, there had been an even more moving expression of affection between the two leaders. (Photo: Calvin Campbell)

M.I.T.'s Next President: "An Engineer from the Earliest I Can Remember"

"I was convinced that engineering was for me and M.I.T. was the place to do it."

When he left M.I.T. in June, 1955, with a shiney new master's degree, Paul E. Gray, '54, never expected to come back. "I'd had it up to here," he says with a hint of a smile, one hand gesturing at nose level.

That was after five years of being a full-time electrical engineering student — by every measure a successful (though perhaps not outstanding) one. He was ready for something else — two years in the army to fulfill an R.O.T.C. commitment and then his first job at RCA Laboratories in Princeton, N.J.

But it didn't happen that way.

By early in 1957 Professor Thomas F. Jones, Sc.D.'52 (he is now M.I.T.'s vice president — research), with whom Dr. Gray had worked for three years as an undergraduate, had launched a campaign to persuade his protégé to return to Cambridge to be a teaching assistant and pursue a doctorate. Dr. Gray finally gave in. "I had been away long enough so that the place didn't look so bad," he recalls.

And so began a faculty career which climaxed on October 5, 1979, when Paul Edward Gray was elected by the M.I.T. Corporation to be the Institute's 14th president, beginning next July. He has been chancellor — the Institute's number-two administrative leader — since 1971.

An Early, Unanimous Vote

By the time it was announced, Paul Gray's selection was one of least-kept secrets in M.I.T.'s history. But the decision was not made lightly. Carl M. Mueller, '41, chairman of the Corporation search committee, told *Technology Review* that at least 75 names were seriously proposed — "people we had to think about." In due course that list was cut down to 25 and finally to 15 who

Robert Reinhold of the New York Times *takes it as a given that a president of M.I.T. is likely to be a "major public spokesman for science." Not surprising, then, that Paul E. Gray, '54, had an attentive audience for his press first conference as president-designate on October 5. Dr. Gray admitted that he thinks the U.S. may "have lost a certain edge in technological innovation." But he told Mr. Reinhold, "People have come to realize that (our) problems, though they have been created to some degree by science and technology, are going to require continuing technological attention for their solutions." (Photo: Calvin Campbell)*

were interviewed in depth — "the only way to be sure you're not missing someone," says Mr. Mueller.

(Meanwhile, speculation in the M.I.T. community centered on only three candidates — Dr. Gray and two members of the faculty on leave in prominent government posts: Professor Frank Press, White House science advisor, and Professor John M. Deutch, '61, under secretary of the Department of Energy.)

Throughout the whole selection process the Corporation committee worked harmoniously with the advisory committee of faculty members appointed by the chairman of the faculty — joint or parallel interviews, evaluations, discussions.

Only when all this was finished did the two committees turn to the decisive task of comparing candidates. That was late in September, and the first meeting of the Corporation committee with this task on its agenda turned out to be its last — an early, unanimous vote.

Engineering First and Always

Dr. Gray's commitment to engineering is simple and strong. "From the earliest I can remember I had an interest in doing things with my hands — in electronics, in and under autos, in how things worked," he says. "I'm very clear about my motive for being an engineer. My father worked all his life for a public utility as a load dispatcher. The people he looked up to were engineers." The question of what to do with one's life was answered by his father with no hesitation — be an electrical engineer. And there was only one place to learn that: M.I.T.

"So when my relationship with M.I.T. began with a letter to B. Alden Thresher, '20, director of admissions, in 1950, I was convinced that engineering was for me and M.I.T. was the place to do it."

After fulfilling this ambition with bachelor's and master's degrees in five

Though Paul E. Gray, '54, was by no means a "big man on campus," the qualities which led to his selection as president-designate of M.I.T. are recalled by many who knew him as a student. Thomas F. Jones, Sc. D. '52, vice president — research, credits Paul as an undergraduate employee with a new system to calibrate six laboratory instruments an hour when the best his predecessors could do was one a day. Those who knew Paul Gray as president of Phi Sigma Kappa (he's leaning over the curved railing at five o'clock in the picture up the stairwell, right) speak of quiet, effective leadership. And his success as a teacher was recognized in 1958 when Professors Jerome B. Wiesner and H. Guyford Stever gave Dr. Gray an award for excellence in teaching. (Photos: M.I.T. Historical Collections)

PAUL EDWARD GRAY
ΦΣK

35 Lexington Drive
Livingston, New Jersey

Born February 7, 1932; Entered—Freshman; Prepared at Grover Cleveland High School, Caldwell, New Jersey; VI-Electrical Engineering; Dean's List 8 terms; American Institute of Electrical Engineers (4); Eta Kappa Nu, Vice-President (3), President (4); Nautical Association (1, 2, 3, 4); Student Faculty Committee, Electrical Engineering Department (2, 3); Tau Beta Pi (3, 4); Wrestling (1, 2); Weight-Lifting Team (1, 2, 3).

years here, why was Paul Gray's enthusiasm for M.I.T. so dampened that he never wanted to come back? It's not an uncommon disaffection among new graduates, and Paul Gray thinks he understands — "a likely consequence," he says, "of an education that provides no constraints on what to study or do and opens a host of captivating opportunities. The place will give you all the rope you want — and enough to hang yourself," he says. But that richness, flexibility, and open attitude are what Dr. Gray values about M.I.T., too.

"M.I.T. Under Our Skins"

"Whatever impact the 14th president may have will be overshadowed by the contributions of his 13 predecessors. Our opportunity comes because we can stand on the shoulders of those who preceded us."

For Paul Gray and his family, their association with M.I.T. has shaped their lives, "a richly rewarding experience," Dr. Gray told the Corporation at its luncheon on October 5. He's been accused of an irrational loyalty to the Institute, but in fact he feels "a deep and abiding love for an extraordinary place . . . M.I.T. has gotten under our skins."

The Grays both feel close ties with alumni. "One of the most satisfactory aspects" of his years as chancellor has been interaction with alumni, Dr. Gray told *Technology Review*. "The Institute has been built largely on the basis of alumni support, and we'll need it in the years ahead — in both financial and human terms."

As experience for his new job, Dr. Gray says he has had a "remarkable apprenticeship" in serving with Dr. Wiesner, and he would not trade that for any other experience he can imagine. He feels it's a fortunate tradition at the Institute for M.I.T. to grow its own leadership; results are a strong thread of continuity. "Whatever impact the 14th president may have will be overshadowed by the contributions of his 13 predecessors. Our opportunity comes because we can stand on the shoulders of those who preceded us," he told the Corporation.

"Beware of what you want – you just may get it," was the warning in a Chinese fortune cookie which came to Paul E. Gray, '54, a few years after he became chancellor. Dr. Gray still has that wisp of paper in his billfold, and his pride and delight in the events of October 5, when he was named president-designate of the Institute, could not be concealed. The pictures show him greeting members of the faculty after a standing ovation at a special faculty meeting, greeting Mrs. Karl T. Compton after the Corporation luncheon, and with members of The Tech *at his first press conference as president-designate. (Photos: Calvin Campbell)*

"Surrounded by Insurmountable Opportunities"

The decision to throw his hat in the ring among those being considered for M.I.T.'s president came after much thought. "I said yes, that I wanted to be considered, for two reasons," he explains: "Having worked closely with Jerry for the last eight years, there was a natural human desire to do it myself. And while it's a difficult time for the Institute, I thought maybe some of my experience and insights I've had could be useful and I'd like to try."

His delight — and that of the M.I.T. faculty — was very evident at the special meeting of the faculty to announce the choice of a new president. Dr. Gray spoke after receiving a standing ovation: "It's an occasion when it's hard to find words to communicate my sense of appreciation," he began. "Let me borrow a phrase from the comic strip Pogo: 'We are surrounded by insurmountable opportunities.' We must sort out those opportunities and select those that seem appropriate for this institution — planning, charting, making that future. Through all manner of times, stresses, issues internal and external, the faculty and administration have thought of each other as partners. That tradition has been an enormous wellspring of strength for M.I.T. in the past, and I know it will be in the future.

"There is not much more a president-elect could look forward to."

"An Invention to Deal with Inflation"

What of the problems M.I.T. must face? Dr. Gray is optimistic that the Institute can have the stature and capacity in the future that it has enjoyed in the past. But, he says, if the economic climate continues, it will be a tough ten years for higher education. "We need an invention to deal with the problem of continuing inflation. . . . And we're going to need all the good will that was evident in that faculty meeting and a lot more besides."

"Core Activities in . . . Engineering and Science"

With Dr. Gray's appointment came some friendly scrutiny from the press. His views in response:

☐ On the liberal arts and technology:

The problems of engineering grow out of a social and economic context, and people are more concerned now than ever before about the impact of technology on society. Those concerns must lead us to maintain and strengthen our educational programs. Students now need a fuller understanding of the role engineering plays in society.

☐ On engineering and science in education:

"We are distinguished from other universities by our traditional and pervasive emphasis on the concepts and modes of inquiry fundamental to science and engineering," Dr. Gray says. "If we are to be true to our mission and special character, we must keep an unswerving commitment to the quality

"We must keep an unswerving commitment to the quality and vigor of our core activities in engineering and science . . . while, at the same time, fostering the growing interaction of these fields with the needs and concerns of the society."

An historic moment following the Corporation luncheon on October 5, with five M.I.T. presidents and six first ladies gathered in a single picture. Left to right: Julius A. Stratton, '23, Margaret Compton, Elizabeth Killian, James R. Killian, Jr., '26, Catherine Stratton, Betty Johnson, Howard W. Johnson, Laya Wiesner, Priscilla Gray, Jerome B. Wiesner, and Paul E. Gray, '54. (Photo: Calvin Campbell)

"We must, above all, not let our vision be dimmed or our reach be limited by a climate of retrenchment or a preoccupation with 'survival.' "

and vigor of our core activities in engineering and science . . . while, at the same time, fostering the growing interaction of these fields with the needs and concerns of the society," he says.

☐ On federal policies toward education:

He is concerned about changing attitudes — particularly in agencies that support academic research. He feels that the definition of research is becoming more specific, narrow, and mission-oriented, to be funded in fragments. These actions reflect a growing Congressional skepticism about the values of higher education and the nature and purpose of basic research. The risk is that creativity will be impaired and the development of new knowledge limited.

☐ On minorities at M.I.T.:

Throughout his career in the M.I.T. administration, Dr. Gray has been identified with aggressive efforts to make M.I.T.'s educational programs accessible to minorities and women and to expand employment opportunities for these groups. If we fail, he says, the Institute will foreclose "the contributions we can make to solutions of the corresponding national dilemmas and circumscribe the human dimensions of this community."

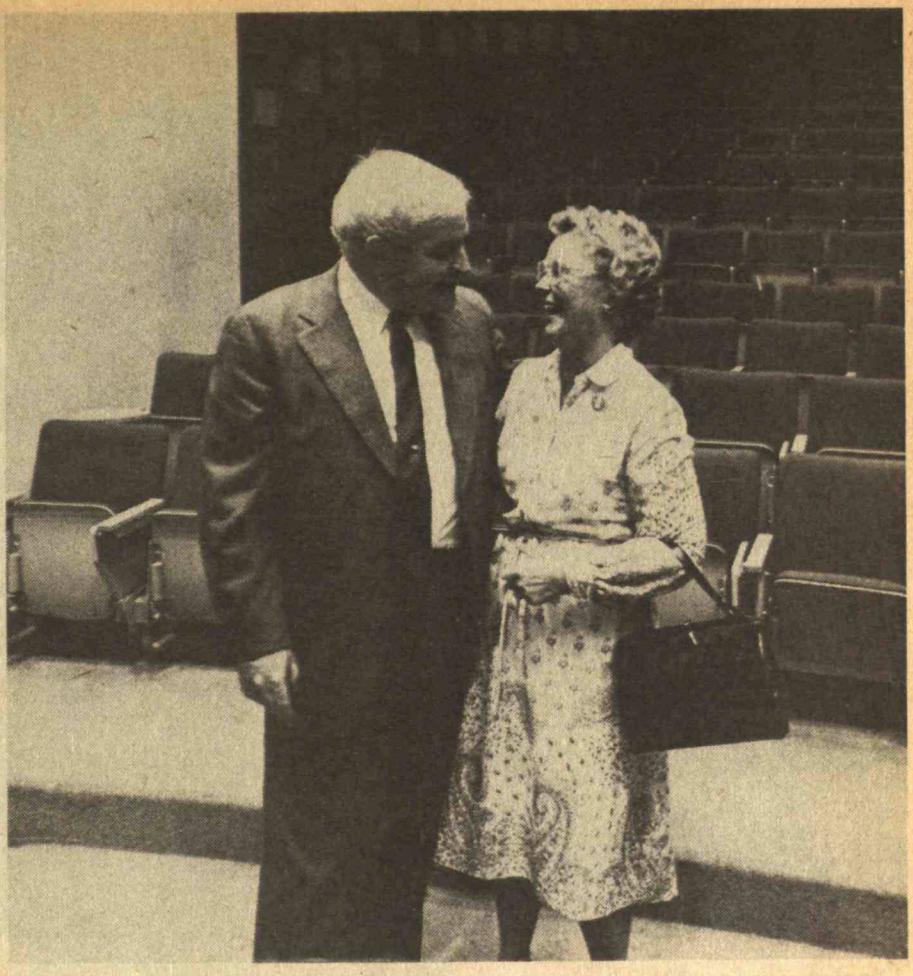
☐ On education:

The faculty takes responsibility for educating the person, says Dr. Gray, "not just the future professional in a specific field. It is in the undergraduate years that students should learn to examine the basic conditions and assumptions about self and society, to explore different ways of thinking, and to relate these different intellectual styles and concepts to each other — as well as to develop the critical talents and knowledge which will form the cornerstone of their professional growth.

Seize the Times — They Are the Only Times We Have

Dr. Gray is looking forward to opportunities, "to seize the times and make the most of them. The 1980s may not be the best of times for higher education, for science and technology, or for basic research. The are the only times we have, however, and we can — in the good old M.I.T. tradition — use them to pursue quality and innovation and to make the bold moves that will ensure 'world space' for the Institute in the future. We must, above all, not let our vision be dimmed or our reach be limited by a climate of retrenchment or a preoccupation with 'survival.' " — *J.M.* and *M.L.*

Introducing M.I.T.'s new president at the Corporation luncheon on October 5, Howard W. Johnson, chairman of the Corporation, proposed that any M.I.T. president "comes into his awesome task as a partnership." It's clearly true of Paul and Priscilla Gray, shown in this picture after his ovation from the faculty earlier that noon. (Photo: Calvin Campbell)



Priscilla Gray: "There's No Way to Separate Us from M.I.T."

Priscilla King grew up in southern Massachusetts and studied at Wheaton. But as wife of Paul E. Gray, '54, she's been part of M.I.T. for 28 years, and she rejoices that her close engagement with every part of this community can only become closer when she becomes the Institute's first lady next July.

"We feel very strongly that both of us have a commitment to be available here — open and visible, seeing a lot of students and the whole community," she told me the day after the announcement that her husband would be the 14th president.

Priscilla expects her life to change more than Paul's in some ways. Though the emphasis will be different, his day will look and feel much the way it has in the past decade; he works a long day and often on weekends, and will in the future; he travels now, and he'll travel then, she says. But "I'll be at M.I.T. a lot more, in many different capacities. We certainly will be pulling away from community commitments in Winchester. (In an interview with *The Tech*, Dr. Gray suggested that "more likely than not" he and Mrs. Gray would live on campus in the President's House.)

The feeling of loyalty and concern has long been a part of the Gray family. "When you stay in one place and invest so much time, there's no way to separate us, to become just the Gray's without the M.I.T. influence," she says.

Their four children chose to go elsewhere to college to have identities of their own. Virginia, 22, is a first-year student at Yale Divinity School after graduating from Wesleyan University. Amy, 20, is a senior at Wheaton, where she is studying art. Her interest is in tapestry and stitching and she just had a show, explains Mrs. Gray with understandable pride. Andrew, 18, is a freshman at Middlebury College in Vermont, and Louise, 16, is at the Marvell Wood School in Cornwall, Conn.

So for the first time in 23 years, all the children are gone. It was in the first two weeks that they were alone in the house that Paul found he would be president. "We haven't had time to come to grips with the fact that the house is empty," says Mrs. Gray.

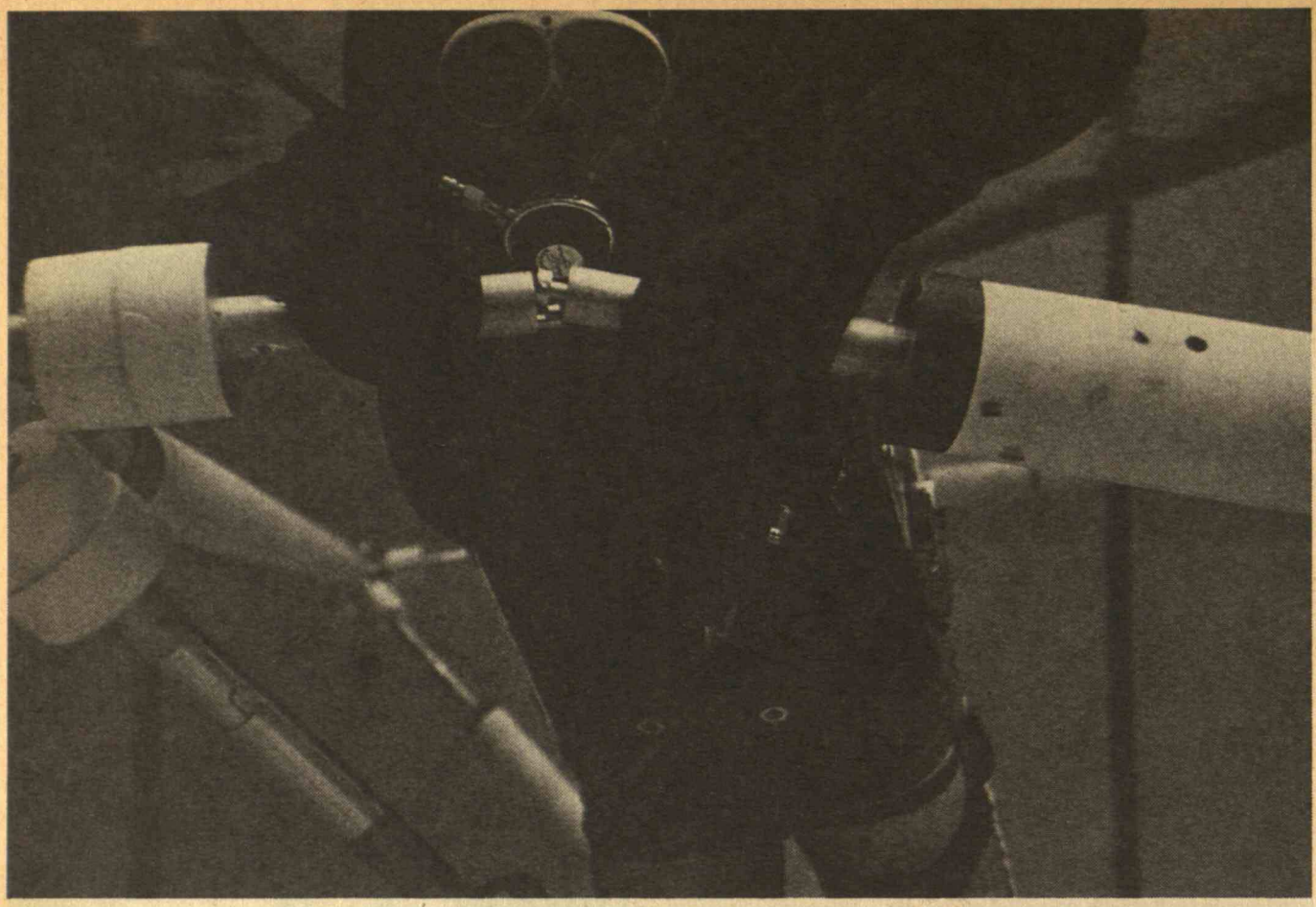
It hasn't been empty often, and won't be. The Grays have always welcomed students into their home. "Those kids are special to us," she says. "I can't remember a time when Paul hasn't had freshman advisees. We're having 16 or 17 out for dinner — that represents three or four generations of advisees. They love to be invited back, and they add such a sparkle to the evening." She hopes many evenings will be filled with such M.I.T. groups.

The Grays are also involved with the alumni, and greatly value that experience. She was a member of the Alumni Officers Conference committee for three years and in 1977 was made an honorary member of the Alumni Association. It's easy to see why: she treasures every opportunity "to see alumni working close up, to see the alumni staff operate, to see how alumni blend into the Institute, to work and get programs off the ground. I've visited alumni groups all over the world with Paul, and it's heartwarming and mind-boggling — it's like a giant family. I could pull an atlas out and stick pins in it and there would be alumni there."

Mrs. Gray reminisced. Paul was a blind date in 1951; he was a sophomore, she a freshman at Wheaton. "He soon beat out all the competition and I went with him all four years," she said. "We still have many of the friends now that are from our school days."

Mrs. Gray was an English major with an education minor — one of the first Wheaton graduates who was certified by the state to teach. She taught second grade at Ft. Devens when Paul was in the army there. Now, she says, she is teaching a subject she loves — embroidery. This is something in which she has been very involved since she and Paul came back from his sabbatical in Wales in 1968.

She describes her time as basically divided into four parts: family, M.I.T., embroidery, and free time — of which more and more gets taken up with the unexpected. Especially now. "The fall," she says, "is off to a runaway start." — *M.L.*



Underwater Space Experiments: from M.I.T. to N.A.S.A.'s Marshall Space Flight Facility

Divers clad in extra bulky wet suits wear harness-like contraptions that completely inhibit their swimming ability. Immersed in the M.I.T. pool, they maneuver by pulling themselves along 10-foot-by-4-inch sewer pipes while clumsily trying to fit them together in clusters to form a tetrahedron configuration. When their structure is laboriously completed, they take it apart and begin again.

The divers are Mary L. Bowden and David L. Akin (graduate students). With a team of six undergraduates and the guidance of Professors Rene H. Miller and James W. Mar, '41, they are studying a question whose elusive and scantily researched answer is essential to the planning of large space stations: What is the productivity of people in space?

They chose to simulate space under water. "Our first concern was to obtain quantitative information on the effect of water drag," explains Professor Miller. So they began to study a simple motion executed by the diver and the forces that affected him or her under water, comparing that with the corresponding forces — or lack thereof — influencing the same motion in space.

To mimic space equipment, they devised a "pseudo suit" out of a wet suit with added rubber to simulate the extra bulk felt in the shoulders, arms, and hands in a space suit. The harness prevents swimming, which a diver tends to do automatically. And to create a man maneuvering unit (MMU — small rocket engines on a back pack used by astronauts), Michel A. Floyd, '80, is building what he calls a PUMA (personal underwater maneuvering apparatus) which is the same idea with propellers.

Video tapes of the divers' underwater maneuvers allow them to calculate what per cent of their time was taken up in aligning beams, clearing face masks, connecting beams, and moving along them. The construction time estimate for space takes into consideration that aligning and connecting time is the same, but the beams would be 40 feet long, not ten, and there would be no extra time used to, for instance, clear your mask.

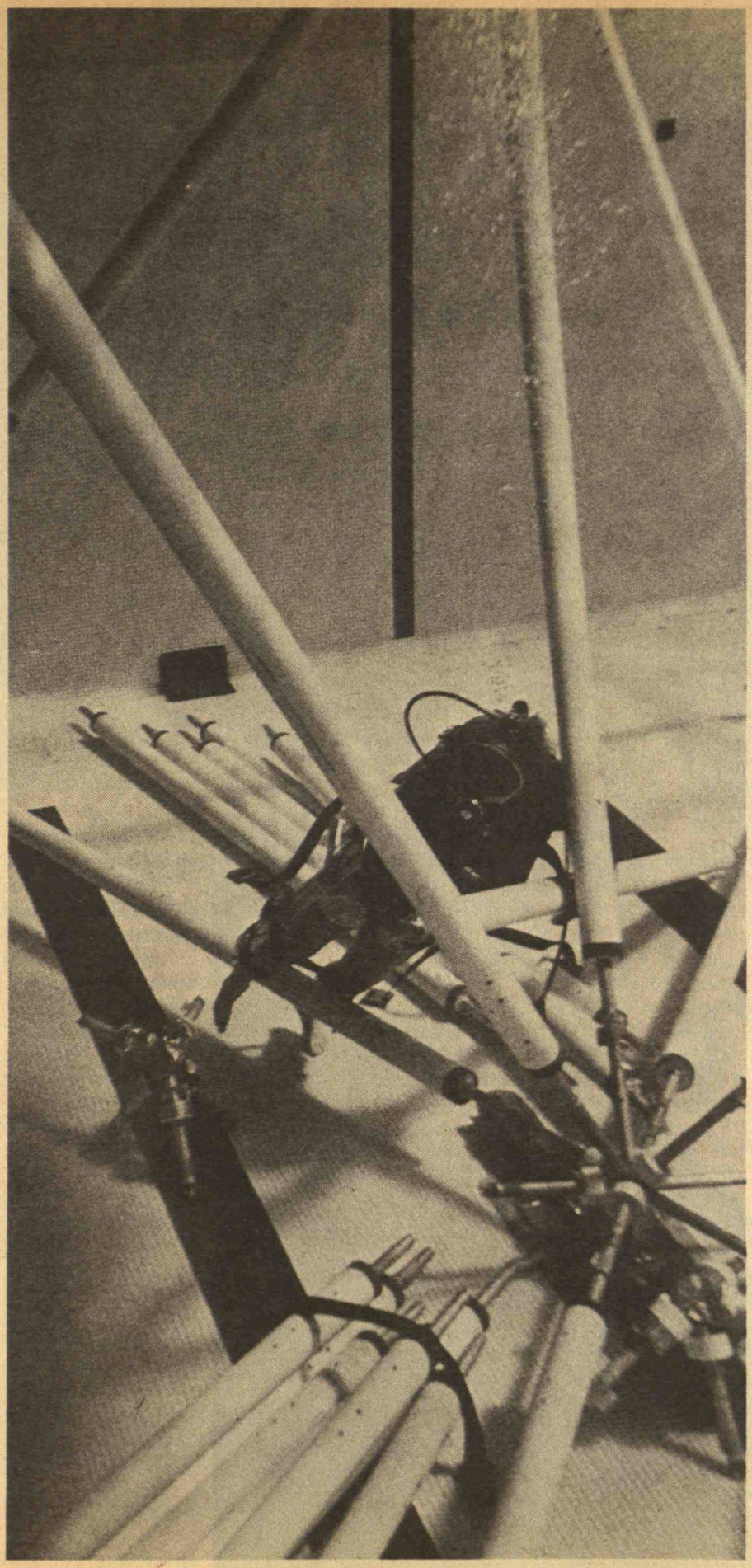
"The heavier the mass is that you're moving, the more it feels like it would in space," explains Mary Bowden. "Basically there are two forces under water, the inertial forces (the bigger the mass, the bigger the inertial force) and drag force. In space, there is only inertial force. Under water, we make the inertial forces much bigger than the drag force, so the drag force becomes a minor influence."

Strain gauges attached to one end of a beam measure the forces on the beams while they are assembled. With the help of a computer program, students learn what forces are affecting the beams during the entire assembly.

"We try to move the beams as fast as possible. But as the speed increases, drag becomes more important," explains Bowden. "It might feel more like space if we worked at a slower pace."

Results: Good Productivity Potential

"Ideally, we should be able to say we



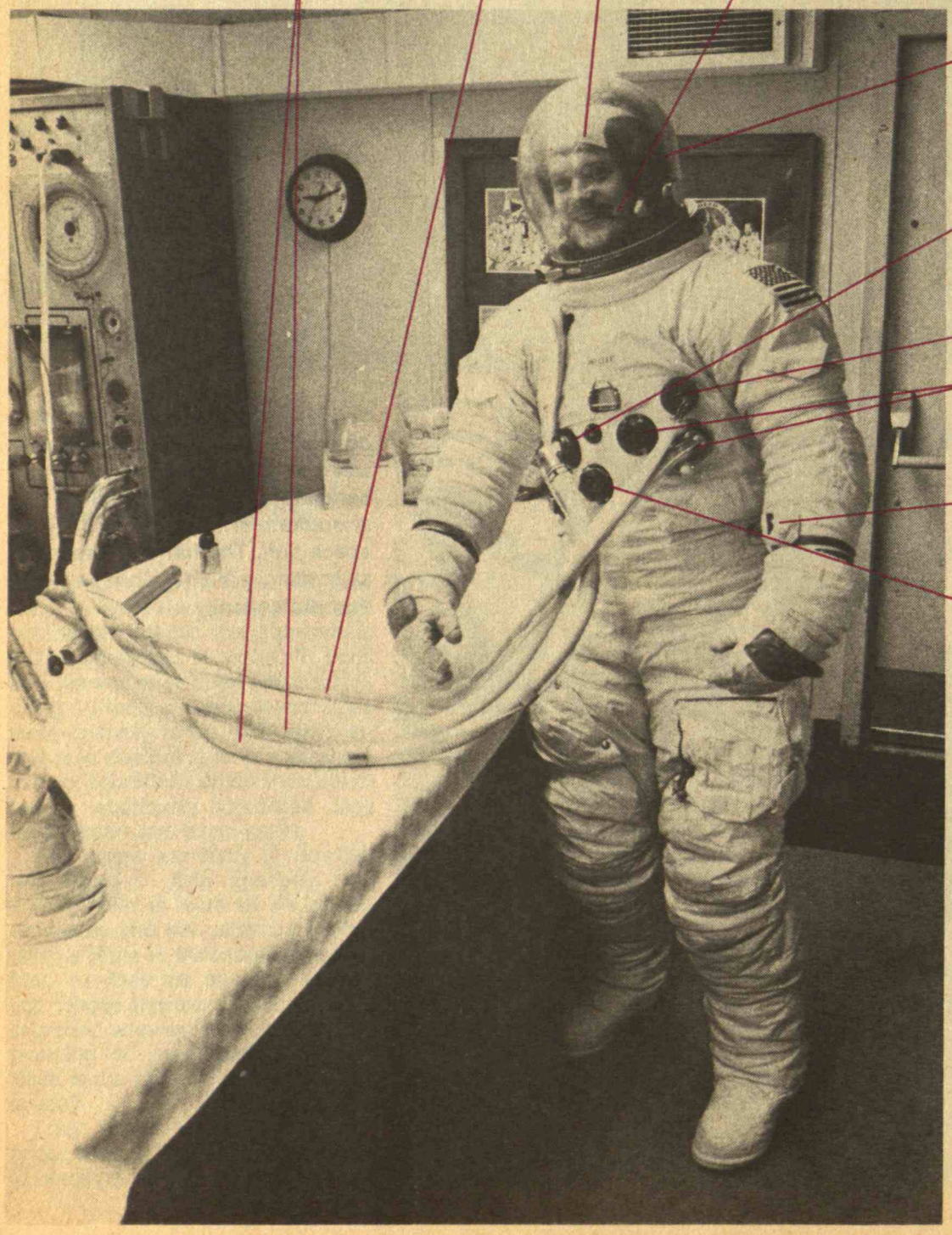
Diver Dave Akin, (opposite page) wearing a "pseudo suit" and harness to inhibit swimming, connects color coded (white, red, green, and yellow) joints of the structure built under water in the M.I.T. pool. The configuration (see page A11 for completed structure) is constructed after the joints and poles are deposited on the bottom of the pool. Two divers work together with other divers nearby for safety. Photos: Michel A. Floyd, '80

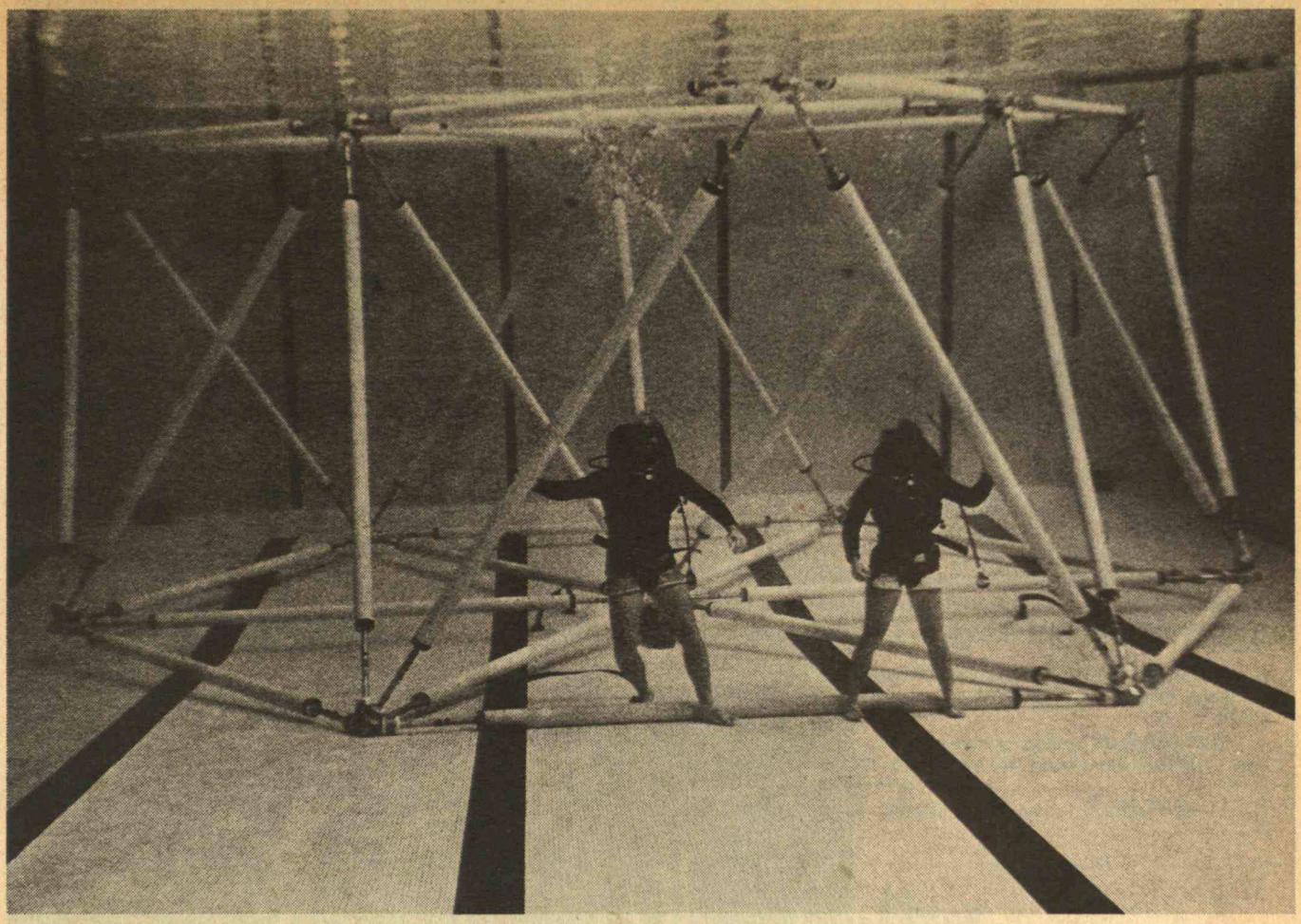
To mimic space equipment, they devised a "pseudo suit" out of a wet suit with added rubber to simulate the extra bulk felt in the shoulders, arms, and hands in a space suit. The harness prevents swimming, which a diver tends to do automatically.

George Sarver, '80, (below) is hooked up to an air machine which pressurizes his suit and sends water through his liquid cooling garment (a pajama-like first layer complete with feet, laced with tiny tubes to carry cool water). The temperature inside the suit is kept at 70 degrees. His helmet is a plexiglass hood that hooks into the collar, popping down into a locking ring. He must push 3 buttons to release it — nothing happens by accident.

It took 15-20 minutes to get in and out of the suit; in space, with training, it should take 5 minutes.

Opposite page: completed construction in M.I.T. pool; divers are Mary Bowden and Dave Akin. Photos: Michel A. Floyd, '80, courtesy Technique





know that people in space suits can put a structure together at a certain rate," says Akin. "Then we could figure out the optimum way to assemble a particular structure," explains Bowden.

And the structure would probably look something like their test model. "If you take an earthbound engineer and ask him to build something in space that is very stiff and light, you could assume that the first structure designed would be like what we built," says Floyd.

Results — and they are conservative estimates — show good productivity potential for humans in space. N.A.S.A. has jumped to the conclusion, say the M.I.T. students, that human productivity in space is low. But this conclusion is based on limited data compiled when astronauts had to extend a solar panel and put a sunshade on Skylab. Small maneuvers while wearing bulky equipment proved a difficult and very slow task for the astronauts.

Tethered vs. Free Movement

N.A.S.A. and the M.I.T. Space Systems Laboratory are following two different philosophies.

"The fundamental disagreement between us and N.A.S.A. is a question of restraints. There is a problem in space of action-reaction. If you put force on something, you get the same force back. It's easy to tumble off the structure. N.A.S.A. would like to tie the worker down with clamps to simulate gravity so the body doesn't float. Then if you apply force, you don't react to the forces you apply," explains Akin.

"Our results suggest that the astronaut does not need restraints. If, for example, you have to swing a beam around to get into position, you naturally adapt without thinking about it. You swing around to where you need to be," he says of his experience in the pool.

Yet the students did have problems at first. Frustration was extreme, explains Akin: "Nothing ever seemed to work right. But after a while you forget about being right side up, and let the beam go where it wants. It's not conscious, but you find soon that when the beam is in the right place, so are you."

"Between our rough-and-ready techniques and their cautious ones, there is a compromise," he adds.

In similar studies, N.A.S.A. researchers are using graphite epoxy — stiff, brittle, light, and easily broken; it's the same material N.A.S.A. expects to use in space. "The beams we use are heavy, but under water they behave *like* beams used in space. If you're worried about productivity, you need to *feel* the same underwater," says Akin.

There is an advantage to the difference between N.A.S.A. and M.I.T. Students push a little harder, because they don't have a lot of preconceived notions. "They don't have 20 years of business-as-usual; they have a fresh approach," says Professor Miller.

An opportunity to go to Huntsville, Ala.

The students who have been diligently experimenting in M.I.T.'s pool on Sundays for two years will have the opportunity to use the Marshall Space Flight Center Neutral Buoyancy Facility in Huntsville, Ala., for a month next January.

The advantage there will be substantial: the use of space suits (critics

Dave Akin performs a linear control experiment in the M.I.T. pool to see how humans control the velocity of a beam in a weightless environment. He is aligning the left girder with the joint at the right; the object is to minimize the impact while bringing the pieces together in a minimum amount of time. Photo: Michel A. Floyd, '80

have called their results to date invalid because they lacked the real thing); a much larger pool (ten feet of space under the construction rather than one inch); and communication — umbilical cords through which they will talk to each other through a central control room.

Tests at Marshall will center on three main areas: learning (how does speed of assembly increase with repetition?); body dynamics (comparing motions under water with motions in space using computer models of the same motion in each environment); and assembling the structure. "We hope we can do it, period," says Bowden. "We might tire out fast, we may get tangled up in the umbilical cords. We'll have to plan movements a lot more carefully than we have been — maybe start from the center and work out," she explains.

Shuttle Bus to Space, and . . .

Possibilities abound with the accessibility of space. "I think it's feasible for 100 workers to put together a 100 sq.-km. structure," says Bowden. They would get up there with the shuttle (it must be reusable to be feasible) which could transport 30 or 40 people at once and return.

Professor Miller's interest is in building a satellite power system to collect solar energy in space and beam it to earth. Material for construction would be brought from the moon.

Will it happen? "It's inevitable," says Professor Miller.

Whatever the risks, all of the students are eager to participate in such a project; Mary Bowden and Dave Akin have already applied to be astronauts. — *M.L.*

Michel A. Floyd, '80, wears astronaut Schweickart's suit for tests. "The space suits are much more constricting than our wet suits. But our M.I.T. pool experiments are not invalid if you imagine that by 1985, the new philosophy of space suit design will produce suits that are much more flexible. The space suits we are wearing were designed for protection, not to allow you free rein to build things," he explains. Photo: Dave Akin, courtesy Technique

M.I.T. INSIGNIA

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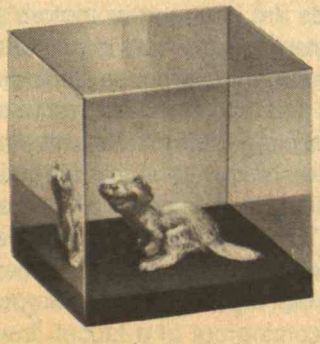

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The irrepressible "Doc" Edgerton caught at his best in the Compton Gallery last year with his favorite audience: M.I.T. undergraduates. One of his colleagues calls Professor Harold E. Edgerton, Sc.D. '31, "the kindest, warmest scientist and engineer I have ever had the pleasure to know." (Photo: Steven Solnick, '81, from The Tech)

The Trick Is the Light: An Interview with Edgerton

"The first subject I worked on was water coming out of a faucet. It was right there in the lab, and the pictures were beautiful. Then somebody said, 'Why don't you try a golf ball?' So it was just one thing after another."

When the G. Ray Hawkins Gallery of Los Angeles mounted a major show of photographs by Harold E. Edgerton, Sc.D. '31, Institute Professor Emeritus, late last spring, the Gallery's David Fahey took the chance to talk with Professor Edgerton. Here are some excepts from his interview, reprinted (with permission) from the gallery's PhotoBulletin:

Fahey: It's been said that your work is a continuation of the work by Eadweard Muybridge and some of the other pioneers. Do you feel an affinity for any of this work?

Edgerton: Well, yes and no. I was lucky to have lots of new technical things at my disposal which they didn't have. None of those people manipulated the light. That's the trick. The thing that differentiates this from all that other high-speed work, like Muybridge's, is that we change the light. Everything he did was with shutters.

What decisions are involved in your choice of subject matter?

Well, when I started out I was an electrical engineer working on synchronous motors. The stroboscope, when it's operated in synchronism with the voltage, shows the motor stopped. Now when the loads are changed or motors are started or stopped there's a very violent transient there which is a little too fast for the eye to see. But with a powerful enough stroboscope I could replace the eye with the camera and record that data and plot it up from a scientific standpoint. So all my first work was trying to get information on these motors. I had a subject and I had to use this technique to study it. I was a one-subject man. It wasn't till later that some of my friends came around and said "Why don't you work on something else?" and I told them "What else is there?" It was then I discovered that the world's full of things that move. Every time you look around there's something that's going too fast for you to see. The first subject I worked on was water coming out of a faucet. It was right there in the lab, right next to my motor, and the pictures were beautiful. Then somebody said, "Why don't you try a golf ball?" And somebody said,

"Why don't you try a hummingbird?" So it was just one thing after another.

Can you give us a layman's explanation of the stroboscopic flash photography and ultra-high-speed photography.

Well, you have to have three things. First you have to have some kind of energy supply, like a battery, and you have to have something that stores the energy so you can release it quickly, because you cannot get power out of a battery quickly. So every strobe unit you carry around has a small battery that slowly charges up this thing called a capacitor. When it gets the energy stored and when you want to take a picture, you trigger the energy from that capacitor. It goes into the lamp and gives you a very short flash. So the lamp is a converter taking electrical energy and putting it into radiant energy. The peak power going into these flash tubes is way up in the thousands of watts. Of course, it only lasts for a short time. The energy is proportional to the peak power multiplied by the time. So when you take a picture of a bullet, you have ten million candlepower for a millionth of a second, so it's only ten candlepower-seconds that does the job. When the light is on it's very, very bright. See the trick?

At what speed are your bullets traveling?

The high-speed bullets, the ones that are hard to photograph, go up to about 4,000 feet per second. Those are the little .22s with lots of powder on them. Very high speed. Ordinary Army rifle bullets go, oh, about 2,000 feet per second. We use bullets as a subject for all the students: we make all our students take pictures of bullets.

Have government agencies and industry come to you with problems which could possibly be solved utilizing ultra-high-speed photography?

Oh yeah. They're a continual source of problems. Well, there hasn't been one in the last half hour, but I suppose the phone's just been busy. There's no end to it. I remember a big testing machine that had some trouble; I took one picture, and the designer immediately said "Oh, ho!" He just couldn't see what was going on. That one picture gave him the whole clue. So, it took a millionth of a second to solve his problem.

Are you at liberty to talk about your involvement with the nuclear program in the '50s in photographing A-bombs and H-bombs?

Well, the problem was to find out what was going on. There were movies taken and still pictures. They've all been used in learning how to make new bombs, or shoot them.

Exactly what did the photographs contribute to the nuclear program?

They were used to measure diameters, determine the color, determine how fast the mushroom forms, that kind of stuff.

In the 1959 edition of Flash *is a photograph of an H-bomb exploding. That was your photograph?*

That's a small atom bomb; that isn't an H-bomb; this is just a little toy. Actually, the photograph was taken automatically. I set up the camera, probably, or some of my friends did. We had a whole battery of these cameras, all triggered photo-electrically. So we just arranged a whole bunch of them and took the pictures.

You've said you're first a scientist, inventor, and electrical engineer — and a teacher as well. I'm wondering at what point does aesthetics come into play or become an issue?

Well, I can't really say because that's not my field. When I see a picture that appeals to me . . . I just took one down in Florida of a little animal in the sea about a millimeter in diamter. I enlarged him up 90 times, and it's beautiful, just beautiful. It's not a very high quality picture because there's a lot of grain in it, but the symmetry . . . I've just been carrying it around. I look at it when I eat breakfast, and I look at it when I get home. I sent it to my sisters, grandchildren. I like it. Is that what you're talking about?

Well, yes. I'm just wondering if there are instances in which exploring the aesthetics of motion is the primary motivator for you instead of just scientific study.

When I'm making a lot of pictures and suddenly see in the darkroom a negative that's got some life and zest, why I stop everything and rush in and try to

"Papa Flash and His Magic Lamp"

The following are excerpts from an appreciation of Harold E. Edgerton, Sc.D. '31, by James R. Killian, Jr., '26, in the latter's introduction to Moments of Vision: The Stroboscopic Revolution in Photography *(M.I.T. Press, 1979, $20.00), copyright 1979 by M.I.T., used by permission.*

Gjon Mili, '27, called him an "American original." A professor of optics at a sister institution to M.I.T. described him as "the kindest, warmest scientist and engineer I have ever had the pleasure to know. . . ." Jacques Cousteau and his staff, with whom Professor Edgerton made ten voyages on the *Calypso*, dubbed him with affection and admiration, "Papa Flash." A distinquished Russian academician wrote of Edgerton's "noble and fruitful career." As his friend and colleague for over thirty years, I sum up my own appraisal by recalling a phrase used by Bernard Berenson in describing an admired friend — "he is a masterpiece."

Harold Edgerton's triumph has been his own life. It was in 1932, while I was editor of *Technology Review*, that Edgerton showed me some of his first and now-classic electronic flash still photographs, and I was delighted to publish a series of them month after month in the *Review*. Thanks to him, the *Review* was the first lay journal to publish a representative collection of his path-breaking photographs. At the same time a widening circle of audiences was finding his high-speed motion pictures absorbing, even astounding. Ever since then, Edgerton himself, together with his students, has continued to explore the absorbing world of fast-motion, penetrating new domains of high-speed events in nature and refining his early transcriptions, papers, and articles in the technical press.

As his novel and pioneering photographs awakened worldwide interest in strobe photography, Edgerton's laboratory became a mecca for people who wished to learn his techniques or to have him analyze rapid motion with his equipment. At the same time Edgerton himself took the initiative to identify, to see, and to understand what his flashing lights could reveal. He went to New Hampshire to photograph hummingbirds in flight; he went to the circus to capture the spectacular performances of bareback riders. I remember him photographing flying bats, baseball bats, and acrobats; a fancier of tumbler pigeons persuaded him to photograph their strange somersaults; great tennis players, baseball players, fencers, and golfers came to him for photographic analyses of their techniques. When the president of the du Pont Co., Crawford H. Greenewalt, '22, became deeply engrossed in photographing hummingbirds, he turned to Edgerton for help and later compiled his masterful portfolio of color photographs of hummingbirds in flight, a classic of natural history. Altogether it was a colorful parade

Continued on page A16

of men and beasts into a new world of vision. In the meantime Edgerton had achieved dazzling visual imagery of running water, milk drops, and bullets.

The Explorer

Explorers, naturalists, and archaeologists as well as gifted professional photographers sought him out, and Edgerton became widely known for his contributions to oceanography. Captain Jacques-Yves Cousteau enlisted his help aboard the *Calypso*, searching under water for ancient sunken vessels and other archaeological artifacts in the Aegean Sea, and exploring sea floors in the Mediterranean, the Atlantic, and Lake Titicaca in Bolivia. When Cousteau embarked on a search for the great hospital ship *Britannic*, sunk by a mine in Grecian waters in World War I, he again called on Edgerton for help. An American group led by Robert Rines ambitiously set out to find the Loch Ness monster — if there is one — and enlisted Edgerton.

Edgerton was a member of a group that set out to locate the sunken Civil War ship, U.S.S. *Monitor*, off Cape Hatteras, North Carolina. During this search, which was ultimately successful, one of the Edgerton-type cameras was caught in the wreck and only recently has been recovered. It now hangs on the wall of "Strobe Alley" at M.I.T. Edgerton has remarked, "One of my favorite preoccupations is figuring out how to retrieve a long list of my cameras lost all over the world."

In 1969, a group of Soviet oceanographers invited Edgerton to sail with them from Britain to Boston via Dakar, Africa, on their elegant oceanographic vessel the *Acadamik Kurchatov*. On this trip he took an M.I.T. freshman, James W. Sholer, '70 (who spoke some Russian), and they demonstrated some of the Edgerton techniques by lowering an underwater camera four times into the rift valley in the mid-Atlantic. By the time the ship arrived in Boston Harbor, Edgerton and the ebullient Soviet oceanographers were singing "She'll Be Comin' 'Round the Mountain when She Comes," and other lusty American ditties.

These are but a few vignettes of the explorer Edgerton. But even as he became world famous and a world traveler, his laboratory at M.I.T. continued to be his base. It is off Strobe Alley, the corridor gallery of Edgerton photographs and equipment that have been recovered from deep-sea waters. Even though he technically retired ten years ago, he is still a magnet for students, and he gladly teaches in both laboratory and classroom.

work on it. Sometimes I'm way wrong. I get real excited about a picture and nobody else likes it. And other pictures I don't think are any good, everybody raves about them. So I consider myself a very poor judge.

Would I be correct in saying that you are primarily the inventor of the strobe as we know it today?

Well, that's what a lot of people say. I have a lot of patents that apply to it. Yes.

What about your studies and developments concerned with the side-scan sonar in archeology and geology.

Now this is important. I've been on many expeditions, and I'm getting ready to go on one. These keep coming up all the time. I got into sonar through the electronic flash or strobe because we were taking pictures down there and the sonar helps to tell where to take the pictures. You need guidance to get you in the right place.

Can you explain how this works?

Well, the simplest one is if you put a camera down on a string in the ocean, you've got to stop it before it gets to the bottom. If you put it in too low, you put it in the mud; if it's too high you won't get a picture. So by having a small sonar right on the camera you can measure by sound the time it takes to go from that transmitter to the bottom and back up to the ship. And you measure that compared to the signal that goes directly up to the ship, and the difference tells you the distance the camera's off the bottom. It's almost like a miracle. You sit up on a ship and know that your camera's so many feet off the bottom, and you can do something about it up there by letting out more cable. That works out fine . . . that system.

Sometimes it's difficult for us as laymen to understand the world of accelerated technology, and quite often we're not prepared to cope with scientific discoveries which have been manifested in all forms of social existence. Do you see that as something holding back your studies or experiments?

No, not really. But there's a big lag. It's amazing to me how long it takes to get a good idea going. That's just because most of us are creatures of habit. This flash photography business we're talking about now, when it first came out in 1930–35, you could see the handwriting on the wall . . . what was going to come . . . but it took years and years and years. I talked to an old fellow who was working in this field and he said, "Well, you have to figure on five years if a brand new, exceedingly exciting thing happens today and you work on it as hard as you can. You'll still be pouring effort and money into it five years from now. It takes that long to get a new idea going."

What's your feeling about the future for photographic recording systems? Where do you think it's heading?

Well, the interesting thing is that we still use the same old silver system that Fox Talbot used in England in the 1860s. You can't get away from the silver process. Maybe we will, maybe we won't. Right now there's a tremendous stirring in the tape people and in the electronic recording people. Who knows? I can't say. But you'll always need light, and electronic flash will always be needed. As they get more and more efficient, of course, you won't need as much light. So that's an advantage.

What future predictions might you make of things that haven't been developed yet?

Well, I don't know any. If I did I'd be writing them down in my notebook real quick and pushing them. Right now I'm working on plankton photography: I'm up to my ears in plankton, and I've got all kinds of problems — how to get the camera down deep. I was out yesterday with a bunch of students, and I was talking to some this morning. We just rebuilt the camera and we're getting ready to go on an expedition.

What is your feeling about documentary photography now being sold as fine art in galleries? Do you have an opinion, one way or the other, for or against that activity?

Well, I'm all for it, because some of the people discovered my work and think it's art. Some of them like it, so why not? I think art is also judged by the eye of the beholder, so if somebody likes it, well, that's great.

05

Gilbert Tower, temporary class secretary, is still alive and active, but has failed to send in class news — the reason being that there hasn't been any. I keep very busy writing articles for the local papers in regard to town problems.

I imagine **Bill Spalding** is carrying on in Norfolk, Va., but I have not heard from him recently. If any of you have news of '05 classmates please send it to me; it would be gratifying to keep the flag flying. — **Gilbert S. Tower**, Secretary, 35 N. Main, Cohasset, MA 02025

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Maurice Root wrote in August that his moving from his long-time home in West Hartford, Conn., to a new home in Maine completely blocked his hope of coming to our reunion in June. He said that although he spent only one year at the Institute, it was one of the most valuable experiences of his life. "Will Sedgwick, my adviser, started me on a remarkably satisfying lifetime career. His writings and teachings, and those of his pupils, inspired me throughout the years so that I've always felt a great debt to M.I.T."

After graduating in medicine from Cornell, interning in New York City, serving in the National Guard and other professional experiences, Dr. Root returned to West Hartford, where he was a leading physician for many years. He also held important staff positions at Hartford Hospital and did a good deal of teaching, writing and lecturing. Dr. Root's new address is 101 Beech St., Rockland, ME 08481.

A. E. Gerald Collins died on July 1, 1979, at his home in Bromley, Kent (near London, England), at the age of 87. He was born in Camberwell, now part of greater London, and when he was five years old came with his parents to Denver to live. He was with us all four years and received his bachelor's degree in Course III. In World War I he was a captain in the Royal Engineers and was awarded the Military Cross. After that war, he joined the staff of the Air Ministry and engaged in building R.A.F. stations in many parts of the world. During World War II he was stationed in Singapore, Ceylon and Australia.

In 1945, Gerald was made a commander of the Order of the British Empire, and two years later he was appointed director of works of the Air Ministry, an office he held until his retirement in 1952. From 1946 on, his home was in Bromley, where he helped to reestablish the Bromley Lawn Tennis Club and was its grounds secretary for 25 years. In 1930 Gerald married Louise Rebecca Rowe, who survives him, as do a daughter, a son and four grandchildren. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, CT

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Jap Carr, our class agent, reported that we are well on our way to achieving our goal for the class gift at our 65th Reunion. Wonderful! All contributions to M.I.T. for the five-year period ending with our 65th are considered part of the 65th Reunion total. Let's continue to build that total.

Dina Coleman recently wrote: "I am still busy doing bunk fatigue. The various 'Do Good' enterprises are doing fine. When some of the gorgeous blond fund raisers 'who profess to love me dearly' invite me to lunch it is always best to take some blank checks. George Kettredge, '17, spent some days with me at Grand Canyon in June; am now booked on a cruise on the Arkansas River for mid September. I think I am caught up on travel in Europe and plan to concentrate on the United States and Canada. In January, 1979, I was voted the Most Outstanding Citizen of the Greater Lexington Area for 1978. I accepted it in the name of the hundreds of volunteers who have accomplished what I was receiving credit for.

"Last month I was interviewed by a local TV station personality. She asked how I accounted for being alive 86 years and being in such wonderful health. My answer was: 'liquor and food in moderation; no exercise other than elbow bending; and a continuing interest in girls.' The TV station made an extra tape of the interview and the children were highly amused."

Hy Ullian comments on our 63rd Reunion: "Those that showed up are a healthy-looking lot. Frieda, Joe and I greatly enjoyed seeing this group and their wives. . . . **John Gore** writes that he has been having a very painful experience with the shingles. He was hospitalized about five weeks shortly after the first of the year, and "here it is the end of August and my left eye and forehead are still very painful. On the whole, I am getting along OK and not doing too badly for my 85 years." We remember well the many times at reunions when John entertained us with his variety of bird calls and other imitations.

We are saddened by this letter: "**Kermerton Dean** passed away on July 10 in Houston. He had been ill a short time, heart attack and then a stroke. This note is being written at his desk where he has many articles of interest from our very enjoyable visit to his 50th Reunion."

I had nice notes from **"Shats" Ober**, **George Crowell** and **Nat Warshaw** thanking us for the reunion photo.

Keep the letters coming and "keep breathing" and "keep walking." — **Ralph A. Fletcher**, Acting Secretary, P.O. Box 71, West Chelmsford, MA 01863

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We received a good newsy letter from **Howard Melvin** recounting a 2,700-mile trip through the Northwest and giving a brief summary of his interesting career. He says, ". . .arrived in Seattle on August 2, where I had planned to see Edna and **Hobe Stebbins**. When I arrived Hobart had called our son, Louis, and extended an invitation to the three of us for a ride around Lake Washington in Hobe's yacht and for dinner later. Unfortunately, Hobart became ill and their son called having to cancel the boat trip. I did have two phone visits with Hobe and Edna. The last one was just before leaving Seattle and Hobe was feeling better and had been to his office. I am so sorry we missed a personal visit and some 50th- and 60th-anniversary memories of M.I.T. . . . As a part of our trip, we went to Washington State University where I graduated in 1911 and was an electrical engineering instructor in 1912-16 before my year at M.I.T., and Spokane where I was electrical engineer for the Washington Water Power Co., 1920-25, before going to the New York office of Ebasco Services whence I was retired in 1959 as chief consulting engineer. . . . Am sorry not to be able to attend some of the annual class get-togethers but glad I am living in this delightful spot in California. My health continues to be good."

A note from **Ray Brooks** says his doctor wants him to go to the hospital for some more tests to which Ray says "Maybe, but later." In the meantime, he plans to fly to Oshkosh with a pal to a meeting of the "quiet birdmen," which is a group of ex-fliers with Air Force service — all, I believe, Aces. Ray says they will spend a "week of intense living." Ray is getting philosophical: "It perhaps is a mad, mad world, but it's also a world of beauty and serenity if you keep trying to enjoy such beauty and serenity."

Stan Lane and **Stan Dunning** wish to thank all members of the class who responded to their appeal for class dues. "We are again solvent," they say.

Warren Tapley invites classmates to stop by and see him if they are visiting Cape Cod. He lives in West Falmouth. . . . **Leon Keach** advises us that Gertrude and he celebrated their 50th anniversary on June 15, 1979. I am sorry to have to report the death of **George Abbott** on March 31, 1979. George lived in Denver, Colo. — **William B. Hunter**, Secretary, Apt. 8-9, 711 Farmington Ave., West Hartford, CT 06117

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By this time you should have received a bulletin on life income plans at the Massachusetts Institute of Technology. I suggest that you study the various programs which serve both selfish and unselfish purposes. If you have the funds available, the government encourages you to invest in your alma mater. You make a valuable tax savings for yourself and receive a good income on your investment. In the end M.I.T. becomes a beneficiary so that it can continue to train students (even as it did you and me) to make their contributions to a better life for everyone.

Some time ago Jim Donovan, '28 and I recalled fond memories of **Harold Weber**. He told some things Harold had achieved way back in World War I days. Thanks to Jim, here is an interesting history of some of these events. How about stories from you looking back at your own high points?

Harold, a man of wide interests, is still alert but is interested in retiring in Sun City, Ariz. He has always been interested in electricity as well as chemistry and other phenomena. While we were undergraduates he was one of the early men who

had an interest and competence in radio. When our country went to war in April, 1917, M.I.T. was training the Signal Corps who would be flying that "new fangled thing" called an airplane and who would be needing to know something about using a radio to communicate. At this point the Signal Corps and Harold got together; Harold taught the Signal Corps courses and radio operation. Since there was only one Signal Corps radio around M.I.T., Harold brought his own unit in from home. Thus they could communicate from one place to another. Later on Dr. Lewis had Harold join his staff on Chemical Corp projects, and that's where he and **Bill Ryan** finished out the war.

When back at the Institute, Harold continued his electrical interests and had an idea about how to replace the radio tubes (the DeForrest radio tubes which we all used) with a solid-state device. Harold took the idea to Van Bush who gave him no time at all, suggesting he should continue being a chemical engineer. Then much later Harold, while serving as chief scientist for the U.S. Army, had an opportunity to meet Dr. Shockley of Bell Labs and also of transistor fame. Harold described his solid-state concept, and Dr. Shockely said, "That's a field-effect transistor."

So, our classmate way back during World War I thought up a concept which was reinvented in the 1960s! Harold was interested in ideas *and* in people — a great classmate whom I sat alongside of many times in chemical engineering classes.

I am very happy to report that Dorothy Rossman visited Boston in August. We had a most enjoyable reunion for several days — with Dorothy, Elizabeth Howe, and Selma doing the talking, while I managed to get a word in once in a while. All are well. Dorothy has been spending the summer in Maine. By this time, she has driven back for the winter season in Tucson, Ariz.

Faithful **Jawn Abrams**, now settled in Glendale, Calif., contributes an active newsletter. This one is eagerly nostalgic. His maternal grandfather was appointed minister to Bermuda in 1861 by President Lincoln. His paternal grandfather was the first man to haul crude oil from Titusville, Penn., to Pittsburgh by steamboat. Father Abrams continued in the oil tradition, as even Jawn has. — **Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, MA 02146; **Leonard I. Levine**, Assistant Secretary, 539 Washington St., Brookline, MA 02146

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That our 60-year reunion is rated as a success is amply proven by the comments sent to me by those fortunate enough to have been there in person. Even the class picture has been received with acclaim and indeed published by *Technology Review*. Should any classmates desire a copy please write to me.

A letter from **Doc Flynn** tells of a serious surgical operation and I'm sure that any of his classmates who may write him will enjoy his reply.

We regret to report the passing of a popular member of our class, Col. **William H. Bassett, Jr.** Bill died at the Veterans Administration Hospital in Boston. He was born in New Bedford, Mass. and before coming to M.I.T. graduated from the Chesire Academy of Connecticut. Among the accomplishments of his technical career was the development of a metal alloy called "avialite" — an essential in aeronautical engines. His military career encompassed service in the U.S. Army during World War I and active duty in World War II. He was stationed with the Army of Occupation in Japan and later served in Korea during that conflict. He was past governor of the Society of Mayflower Decendents in the State of New Hampshire and was active in many technical and fraternal organizations. He is survived by his wife Louise, his sons William and Dean, his daughter Mrs. Allen Rugg and nine grandchildren and two great grandchildren.

I look forward to a word about you, why not do it now? — **Bill Langille**, Secretary, Box 144, Gladstone, NJ 07934

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Recently I received some heartening news for our class contribution to the Alumni Fund to be announced at our 60th Reunion. The widow of our esteemed classmate, **Carl Carlson**, who died in June, 1978, has released his exceedingly generous estate bequest so it can be credited to our class before the reunion. Carl got his B.S. and master's degrees at M.I.T. and served as instructor in analytical chemistry at the Institute before joining Exxon to help build a new refinery at Baytown, Tex. During World War II he took over supervision of the new defense plant for the manufacture of Butyl rubber. He served as superintendent of the Butadiene plant in Baytown and continued there until his retirement 34 years later. At Baytown, he met and married his wife Erna who was college librarian at the time. The recent mailing from our able estate secretary, **Lee Thomas**, should make us all appreciate the excellent work he is doing. May we wish him deserved success in his untiring efforts.

Perhaps by the time you read these notes you shall have received a communication from your 60th Reunion committee giving advance plans for that great occasion. Hopefully, you shall have written us favorably about your intention to attend. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, MA 01890

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Your secretary has been working like a dog the last two days, cleaning up all the debris left by Hurricane David and making minor repairs to the garage roof where a large tree limb crashed. Ah, me! Having reached the 80-year milestone during the last month and catching up with many other octogenarians in the Class of 1921, I didn't appreciate David. At least two others in our class reached 80 in the past month: **Irving Jakobson** and **Bill Sherry**.

I have been informed that Mrs. Rupert M. Hanny has made a substantial gift to M.I.T. to establish a memorial scholarship in honor of her first husband **Maurice G. Townend**, who died in 1947. Townend, known as "Moxie," served in World War I to fight "The Battle of Harvard Bridge." In his business career he became vice president and director of Parks-Cramer Co. in Fitchburg, Mass. While working as manager of the southern branch of Parks-Cramer in Charlotte, N.C., Townend was treasurer of the Charlotte Engineers Club. He was an accomplished pianist and was remembered most for his music. For this reason the memorial scholarship fund is intended for students who will most benefit from courses in the humanities. Townend was "a man of integrity and a leader."

Assistant secretary **Sam Lunden** has sent me a resume of **Merritt Farren**'s career and an interesting tale of Farren's experiences in France during the summers of 1921 and 1922. This will require drastic condensation, but here goes.

"It was one of my greatest honors to be selected by Dean Emerson (architecture) to represent M.I.T. in the Harvard Reconstruction Unit working in France in 1920. Four of us sailed in May and 30 arrived a week later. We were divided into three groups: Rheims, Somme-Py, and Claremont in the Argonne.

"The railroad ran once a day between Rheims and Somme-Py which was two kilometers from the Hindenburg Line. Thirty feet below ground the Germans had had a telephone system connecting all principal cities and military headquarters. Four of us lived in a tarpaper hut put up by the Red Cross. Leon Keach of Tech was with me and at our first meeting with the town fathers we were asked to prepare drawings for the restoration of the Marie Ecole and Museum. This we did and President Millerand of France drove out from Paris to thank us. (In 1936, Mrs. Farren and I saw the town hall quite as we planned it.) Leon and I on time off would strap on our knapsacks, walk six miles to the railroad at Suippes and see much of France. We visited the cathedral cities and various chateaux.

"The following summer, the unit became the American University Construction Unit and returned again to France. This time the M.I.T. architects were the late **Christopher Carven**, **Sam Lunden** and others."

From 1921 to 1928, Farren worked for various architectural firms. Designs included the Nebraska capitol and the chapel of the University of Chicago (sanctuary carvings). From 1928 to 1931, he was in partnership with Kenneth Dalzell of Short Hills, N.J. From 1931 to 1949 he worked as designer and interior decorator for various concerns, including W. and J. Sloane and John Wanamaker. During a leave of absence from W. and J. Sloane in 1936, Merritt was the architect for All Saints Chapel of the Church of the Ascension in New York City. This included all plans, elevations and details of wood and stone carving. Later in the church itself, he designed the World War II memorial and stained glass windows.

From 1951 to 1956, Merritt was business manager of the craft program, personnel and income-producing activities at Old Sturbridge Village. In the 20 years from 1956 to retirement in 1976, he was back in New York with B. Altman and Co., contract decorating. Jobs included the presidential dining room in the Mayflower Hotel in Washington and reproduction of President Truman's Oval Office at the Truman Library in Independence, Mo. A most interesting career! Merritt and his wife live in Lakewood, N.J. and report good health.

Speaking of **Sam Lunden**, a December, 1978, newsletter of the Lyon Group of Architects, which has just come into my hands, tells of his joining the firm as a consulting architect in Los Angeles. The firm of Lunden and Johnson was dissolved in 1978 when Johnson retired. Sam is a Fellow of the American Institute of Architects, a past national vice president and past president of the California chapter. Major projects of his include university buildings, banks, urban renewal master plan, medical center, and the Doheny Memorial Library. Sam developed the forerunner of conductive ceramic tile now in general use on hospital surgery floors. He and his wife Leila spent this past summer and early fall at their Cape Cod cottage in South Dennis.

An Alumni Fund envelope from **A. Abba Orlinger** says: "I am still active — going to my office daily — in patent and trademark law work. It's very challenging and keeps me alert. My wife Sadie is well and happy after 56 years of married life and participates in my work. We have three grandchildren." — **Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, NJ 07450; **Josiah D. Crosby**, Assistant Secretary, 3310 Sheffield Cir., Sarasota, FL 33579; **Samuel E. Lunden**, Assistant Secretary, 606 S. Olive St., No. 701, Los Angeles, CA 90014

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Your Secretary is still suffering from lack of news which is usually available at the June Alumni Day. We don't even know who was there, but hope that the usual loyal group had a pleasant luncheon. We hope to receive news at the class secretaries meeting at M.I.T., but more than ever we depend on the incoming mail at the Buffalo office.

We are sorry to hear from Mrs. Shattuck of the passing of **George A. Shattuck** in July. Her address is: 2535 Cardwell Way, Sarasota, FL 33581.

We also send the sympathy of our Class to the family of **Harland A. Wilbur** of Winchester, Mass. He was President of the Graphic Litho Company of Lawrence and a leader in the development of commercial offset lithography in New England. He had received his LI.B. degree from Northeastern Law School in 1942. He leaves his wife, Helen; a son, Ralph, in Andover; and two brothers.

Please, oh please, write your Secretary. — **Whitworth Ferguson**, Secretary, 333 Ellicott St., Buffalo, NY 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, FL 33060

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Mrs. Helen F. Whitaker, widow of our classmate the late **Uncas A. Whitaker**, has been designated an Honorary Member of our class by a committee especially appointed for the purpose by President **Goetchius**. The Whitakers have been generous benefactors of the Institute in the area of the life sciences, their program now being continued by Mrs. Whitaker through the Whitaker Foundation and the Whitaker Health Sciences Fund. On June 4 ground was broken for the new Whitaker College of Health Sciences, Technology, and Management and the new Medical Department Building, a part of the same complex.

Herman Bruson writes that on June 25 and 26 he gave a talk at Givandon Corporation in Zurich, Switzerland, on "Fifty Years of Inventing Chemicals for Industry" at the invitation of their U.S. subsidiary.

Tom Powers writes that he still is in the hotel business in Fargo, N.D., the business now being run by his sons, Lawrence and William.

At this writing our 56th reunion is about to begin at Mystic, Conn., with 29 expected to attend including **Rod Goetchius**, and we are wondering how he and Hurricane David did at Vero Beach; full report next time. — **Richard H. Frazier**, Secretary-Treasurer, 7 Summit Ave., Winchester, MA 01890

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The excessive heat and humidity apparently developed ennui, sticky forearms and moist typewriter keys this summer, causing a paucity of Notes. We did learn that Jockie and **Phil Bates** celebrated their 50th wedding anniversary on June 23, 1979. At Santa Monica, Calif., they were hosted by their sons and daughters-in-law accompanied by eight grandchildren merging from all parts of the United States. Phil was former general manager for research at the Carnation Co., and currently is editor of the *Journal of Agricultural and Food Chemistry*. Jockie is a Wellesley grad and active in local civic and church affairs.

Bill MacCallum has returned to Massachusetts General Hospital for a checkup on progress of chemotherapy some months ago. Normally, he and Eleanore overlook Nantucket Sound from Cotuit on Cape Cod. **E. Curtis (Dean) Plant** retired in 1971 after 47 years with Public Service E & G Co. of New Jersey, and writes: "Highest priority interest is as Secretary, Board of Trustees, Christ Hospital, Jersey City, N.J."

We have a very interesting note from **Sam Zerkowsky**, Slidell, La., probably the only horticulturist in the class (apologies to **Ed Moll**, Yankee herbalist), owner of Tammia Nursery, Pearl River, La. "Since 1944, my wife and I have lived on a farm in the healthy ozone belt, 35 miles northeast of New Orleans and across from Lake Ponchartrain. We moved there to rear our two daughters in the ozone air and raise horses. We became interested in growing camellias, the world's most beautiful flowers. Now people visit us from Australia, New Zealand, Japan, Great Britain, Europe and many states in the U.S. to see our large and unusual collection of camellia plants. It keeps us busy in our retirement."

Don Moore's daughter, Dr. Sandra Faber, is the first woman to be appointed to a full Professorship at Cal Tech, Pasadena, Calif. She will have access to Hale Observatory, Palomar Mountain with its 200-inch reflector telescope, second largest in the world. — **Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, MA 02146; **Herbert R. Stewart**, Co-secretary, 8 Pilgrim Rd., Waban, MA 02168

25

The summer season on Cape Cod is drawing to a close and we will now be able to go down town and find parking spaces available on the main streets. The winter activities, and there are many,

Honoring Osborne for His "Long-Fiber" Paper

Fay H. Osborne, '22, retired as technical director of the C. H. Dexter Division of Dexter Corp. nearly 20 years ago.

But "his presence is still felt as new technical breakthroughs and new materials continue to issue from C. H. Dexter today," says David L. Coffin, chairman of the Dexter Corp. Accordingly, the Dexter Division's new headquarters and research center building in Windsor Locks, Conn., was dedicated to Mr. Osborne last summer.

It was in the 1930s that Mr. Osborne made his major invention — the "long fiber" process for making specialty papers and nonwovens. It was used almost immediately for new lines of tea bag paper and sausage casings. To them has now been added food packaging, surgical products, diapers, vacuum cleaner bags, cigarette papers, and textile replacements — through all of which "the results of Mr. Osborne's process touch hundreds of millions of people the world over," said Ralph H. Martin, C. H. Dexter president, at the dedication ceremony.

When the C. H. Dexter Division named its new administrative-research center for Fay H. Osborne, '22, last summer, they gave Mr. Osborne an engraved replica of his long-fiber paper patent on which the company has built much of its current success. Mr. Osborne began his technical work for the division in a ten-by-ten-foot lean-to at the back of the mill in Windsor Locks, Conn., shortly after graduating from M.I.T. He retired as the division's technical director in 1962.

will soon be in full swing. Our Cape Cod Club has plans for several meetings. Hopefully, the classmates on our mailing list will attend.

Ernie Stone was the only classmate who showed at our recent picnic held at the Allen Harbor Yacht Club in Harwichport. Ernie seems to have weathered the years in fine fashion.

We have a fine historical society in Chatham with a 1752 House and Museum open to the public during the summer months. It is hosted largely by volunteers and when I dropped in a few weeks ago I found **Will Mahoney** hosting the Joseph C. Lincoln Room, a room memorializing the author of many Cape Cod books. Will appears to have enjoyed a good summer and was well tanned from his boating and other outside activities.

You should shortly be receiving word from our 55th Reunion committee. **Courtenay Worthington** has been in touch with me and reports that planning is underway.

A note from **Sam Maddock** in Portsmouth, N.H., says "I write a few non-technical articles which are touched with printer's ink." It was nice to hear from Sam after many years. . . . **Harold Bishko** writes from San Diego to tell us that he is "alive and happy again (after a lengthy siege of illness) in sunny southern California, and occasionally visits with five children and nine grandchildren." — **F. Leroy (Doc) Foster**, Secretary, 434 Old Comers Rd., P.O. Box 331, North Chatham, MA 02650

26

Since the Class of '26 has never missed an issue of notes, we are telephoning this month's. This claim is made without research, but we know that our previous class secretary, **Jim Killian**, *never* would have missed an issue.

Being flat on one's back in a hospital complicates things a bit. In early August indications were that my right carotid artery (to the brain) was badly clogged. Tests started at Mass. General Hospital confirmed this fact. A dear lifelong doctor friend explained that there was practically a 100 per cent chance of a massive stroke. So, right after labor day, the artery was opened and cleaned out (enganterectomy).

I've given you the gory details because there is a fairly simple test your doctor can perform on your annual physical with his stethoscope by holding it against the carotid artery in your neck. He can hear the blood squeaking through the artery if there is a problem, and there is even a name for it — "brie," which is French for noise. This crazy thing doesn't happen often, but I think you will agree it is worth listening for. I was hospitalized longer because my heart tests were exhaustive, and I also caught pneumonia at the end.

Consequently, we missed **Jim Killian**'s 50th wedding anniversary hosted by his son and daughter, but Jim called us at the Mass. General Hospital and described the gala affair. Belated congratulations to Jim and Liz! We did not, however, miss my 75th birthday of September 18. Ruth banked the room with red pinks; the hospital cook made a cake; and the nurses poured into the room singing, "Happy Birthday."

Now I can tell you that these notes have been written on a soft balmy Autumn afternoon on our terrace overlooking the sea, with a single sailboat on the horizon and the sun shining almost horizontally on the new Pigeon Cove breakwater. This, I can assure you, is superior therapy to the hundreds of pills that have been my diet for weeks. "Stick with the sun and listen for the breeze." — **George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, MA 01966

27

This summer we lost three stalwarts of our Class. **Jim Lyles** our president in undergraduate years and president and honorary president thereafter throughout his lifetime; **Joe Harris**, our conscientious secretary for all the years from 1927 until 1973; and **Joe Melhado**, who dutifully carried on as Secretary since 1973 until June when his daughter-in-law Ruth helped prepare our class notes. All three deserve the recognition by their classmates of the many hours of time, thought, and writing to bring about a spirit of unity and friendship within our class.

We visited Marion Melhado recently in Scarsdale and received first-hand information on Joe's struggle with cancer. With his strong heart he lived three weeks longer than expected until it spread into his lungs. We took away with us the four cartons of class files started by Joe Harris; they amount to a documentary on each of the classmates from whom we have ever received notes. Joe Melhado Jr. and his wife Ruth were there and we thank them for their help.

Talked with **Ray Hibbert** on the phone. He is one of the few classmates still at work — selling plastic moulding machines for AAA Plastics Equipment Co. of Fort Worth. He and a 70-year-old partner are doing well in selling and servicing these essential machines for parts for refrigerators, autos, etc. . . . **Carl Davies** is another still active in the wholesale lumber business and will have more now after surviving Hurricane David that hit his Charleston and the southerly island of Hilton Head. . . . **Judy Priest** has a bad elbow and reluctantly has to give up his tennis.

Francis (Frank) Thorne and his wife Ruth celebrated their 50th wedding anniversary in Rochester, N.Y., on July 27 at a party given by their three children. They can boast of nine grandchildren and two great-grandchildren. Frank was assistant superintendent of the Chemical Manufacturing Division of Eastman Kodak when he retired in 1964. They now live at 80 Woodbourne Drive, Ormond Beach, Fla.

Your new secretary, **Joe Burley**, and wife Ruth celebrated their 50th wedding anniversary on June 3rd at a reception given by their daughters, Sally, Nancy, and Jane — and with the assistance of three out of four grandchildren. Almost a hundred friends and relatives came from far and wide. It was held in the grounds of their old (1743) Milton home, and the musical background was taped recordings of old 78-r.p.m. records of the good old days of Guy Lombardo and Andre Kostelanetz.

One of the projects Joe was handling was the collection from our classmates of the identification of each one who appeared in our 50th Reunion picture in Rockwell Cage in June, 1977. **Art Connell** writes that it seems unlikely to get any further names so it is a good idea to mail these lists out now to all who are named and presumably have had their picture framed and hanging on their bedroom wall!

When our president, **Bud Fisher**, called me to urge that I take on the secretary's job, I did so with great reluctance because I doubted I could find the time to do as competent a job as my predecessors. So I took it only with the understanding that I am termed "temporary secretary" on a trial basis until elected and until someone with more time available can take over. Presently I am Controller for the Milton Residences for the Elderly, the 140-apartment unit we built in 1973. We are now embarked on construction of another project "Winter Valley Residences" with 120 units, both requiring financial management, records, accounts, etc. Am also chairman of the Milton Historical Commission and on various other committees.

Let these notes close with an appeal to all you classmates who have never said "boo" about yourself or your lives in many long years, to sit down and write some news to me. Many of you will be having 50th anniversaries, too, and I say if you don't overcome your bashfulness now and start crowing about yourself and your family you never will; and no one will speak for you. Incidently, despite our drive to have each class member file his personal history for our 50th Reunion booklet, only 117 responded — not quite 50 per cent. Will the silent majority speak up, find the old form, and send it in? I'll be glad to send the form to anyone who writes. — **Joseph C. Burley**, Secretary Pro Tem, 5 Hutchinson St., Milton, MA 02187

28

In early May, Florence and I took the Aegean Odyssey tour as arranged through the M.I.T. Quarter Century Club. It was a thoroughly enjoyable two weeks of travel by plane, bus, and ship to scenic and historic sites in Athens, Delphi, Dubrovnik (Jugoslavia), Ephesus (Turkey) and the Greek islands of Hydra, Santorini, Rhodes, and Mykonos. Since we were originally to have had a full free day, we had planned to visit with **John Houpis** at his citrus farm in Corinth. A change in the tour plan made this visit impossible so John came to Athens, hosted us at an excellent lunch during which he impressively transmitted our menu selections and chatted with our several waiters all in Greek. Then John guided us on a shopping tour through the Plaka area of Athens and joined our tour group for its cocktail hour. Although John claims to be a bit older than most of us, he is in vigorous good health, and retains his youthful attitude.

In August, while spending a few days at Boothbay Harbor, Maine, we stopped in for a visit with Marjorie and **Bill Bendz** at their charming and unique summer home built partway over the harbor waters on piles. More recently Bill has written to announce that they have now attained the status of great-grandparents. Congratulations! Now let us hear from the rest of you, who else is a great-grandparent?

We are very pleased to have a cheerful letter from **Tom Larson** saying that he is recovering well from his recent operation and is "feeling great." His appetite is good, he is taking daily exercise by walking and hopes to be on the golf course again after he and Lillian return to New Jersey (from Ann Arbor) in late August.

The following brief notes are from Alumni Fund envelope news panels: **Jim Tully** says, "We sampled Florida last winter for two months, propelled in part by escalating fuel costs. While there, we enjoyed attending a meeting of the local M.I.T. Club in Sarasota. . . . **Ben Hough** reports that he is still in active practice and now revising his textbook *Basic Soils Engineering* for its third edition. . . . **Jim Nargis** is still active as an architect. He has just finished his 200th church, the inspiration for which came from a seventh-century Armenian church. His practice now is mostly in restorations. He says all is well and life is peaceful. . . . **Nap LaCroix** during a trip to Bermuda in June enjoyed some personal contacts including a group of M.I.T. '49ers who were there for reunion. . . . **Bob Larson** used his panel for kudos to the class officers and added this request: "Any girls M.I.T. has to turn away, please send them to Wilson College, Chambersburg, Pa., a good school." Understandably, many letters contain words of praise for our hardworking president, **Jim Donovan**. One such from **Eleanor Pepper** is a note to thank him for stimulating and sustaining the class' interest in M.I.T. **Al Puschin**, in writing to Jim, gave words to what many of us have always felt: "To maintain an enthusiasm such as yours for so long a period of time is an achievement in itself. To employ this drive for so admirable a purpose is something else again. My hat is off to you, and I can only add that M.I.T. is so very fortunate in having you as an alumnus."

Now, lest you think that the above expressions are just family sentiments, we have a letter from a gentleman who has no connection with '28. The letter was relayed to us from the Cambridge Historical Society and it reads: "I am a bus operator for Transport of New Jersey. On June 24, I was in Cambridge with a tour bus. I was looking for the Longfellow House and had stopped to ask directions. I was talking to Jim Donovan who said he is a member of the Historical Society. He is a remarkable man. He not only gave me directions, but got on the bus and gave us a tour of Brattle Street. He told us things no tour book would. It was all we could do to find out his name. Two months have gone by and the group still talks about Jim and what he told us about Cambridge. Because of him they are planning another trip next year with more time in Cambridge. We never realized how great Cambridge is. Please say

'thank you' to Jim for us. Like I say, time has gone by and we still think of him." (signed) Tom Mozer. — Let's face it: There is only one Jim Donovan!

Bill Hurst's book, *Reservoir Engineering and Conformal Mapping of Oil and Gas Fields*, is now off the press. As anticipated, it is a highly mathematical production. However, Bill says: " — if you apply yourself, as I have, the subject matter will be self-revealing."

We regret to report the death of our classmate, **J. Conrad Sacco**, in December, 1978. We have no other information at this time. His last address, according to our file, was in Montevideo, Uruguay. To Conrad's family we extend our heartfelt sympathy. — **Walter J. Smith**, Secretary, 37 Dix St., Winchester, MA 01890

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On its charter day luncheon, Thursday, May 17, the University of Hartford gave a citation to **Barrett L. Weston** for having chalked up 45 years of evening classroom teaching in mathematics, the longest on record. Ironically, the news of his death on June 28, 1979, reached me shortly thereafter. Upon his graduation from Course VI (electrical engineering) for 32, he was employed at Pratt and Whitney in Hartford, as an operation analyst. He retired in 1970 from Reliable Manufacturing Co. of Bloomfield, but continued teaching evening courses in mathematics at University of Hartford. He was a former member of the Grarby Board of Education and the Grarby School Building Committee. He is survived by his wife Ruth and five sons and three daughters.

Adrian N. (Cub) Clark has finally sent me his first reply thanking me for the birthday greetings that he has been getting for many years. Adrian attended the 50th Reunion and his resume shows that he was involved in the publication of technical and scientific books with D. Van Nostrad Co. of New York and New Jersey, holding such positions as vice president, editor, and member of the board of directors. The greatest satisfaction of his career has been working with scientists and engineers of distinction for many years, such a John von Neuman, Marshall H. Stone, Oscar Zariski, Samuel Glasstone, Paul Halmos and others, in the development of fine books. His activities and hobbies include travel, golf, choral and choir singing, bird watching, attending concert series in Tanglewood, and others, and one-time membership in Engineers Club of New York City and Down Town Glee Club.

Jonathan McCray, who attended the 50th Reunion, took my picture posing with Jane, the lovely wife of **Bill Young**. He was kind enough to send me a copy with a note saying, "the enclosed picture is another gentle reminder of the wonderful time that we had at Chatham Bars Inn. I was so glad to meet the gentleman who sends me birthday greetings every year. My wife Isabel and I enjoyed attending our first reunion and had a wonderful time during our stay at Chatham, M.I.T. campus, followed by a delightful visit with Teddie and **Jim Fahey** at their home." Jonathan's resume shows that he worked for the Chesapeake and Potomac Telephone Co. of Maryland in various capacities, both engineering and administrative. His hobbies and activities include chairman of the Republican committee of Cleburne County, president of Cleburne County Cancer Board, member of the Board of Directors, American Cancer Society (Arkansas Division), coordinator of Tox-Aide and volunteer income tax assistance for Cleburne County American Association of Retired Persons, and Internal Revenue Service of Arkansas. He also is a member of Cleburne County Election Commission and finds time for a little golf as well.

Frank Mead's wife-secretary Mary, has sent me a brief note saying that, having recovered from the excitements of the 50th, they are leaving on July 23, with some friends for two weeks of salmon fishing on the Ballyhihch River in Ireland. Frank has been busy reaping and freezing all kinds of vegetables from his 100 ft. by 20 ft. garden. In August, Frank will go salmon fishing on the Mirama, then in October he plans to go to Maine for bird hunting, and back there again in November for deer hunting. Mary is wondering if they should not move to Maine! Mary also has sent me a letter she has received from **Ted Malmstrom**'s wife Florence, with permission to use the excerpts for the class notes. "Dear Mary and Frank: Thank you very much for the glass beaver. It is exquisite and one which we will cherish always. I also want to thank you for sharing with us by letter, details of the 50th Reunion activities. **Neal Wells** probably told you that two weeks after we returned from Hawaii, Ted was hospitalized. The neurologist stated later that he either had electrical overactivity in the brain cells or possible seizure. All tests were later found negative. He is OK now. As previously planned, we sold our house and plan to move to Hawaii on August 23. Our older daughter is arriving from Hawaii to help us get rid of anything we can't take with us. Lucky we do not have a cellar; instead, we have a large attic containing items accumulated during a lifetime and sorting through them, we will live our lives briefly over again by memory."

I received a brief note from my newly discovered neighbor and classmate, **Willard J. Slagle**, in response to the birthday greetings, saying, "Thank you for the birthday card. Here I am trying to forget the number of years that are piling up on me, and you don't let me. I like living here on the hill quietly with my wife Ellen, and among other things, I keep a watchful eye on your house near us, while you are in New Hampshire. See you in the fall when you return to Arlington." Bill and his wife Ellen were present at our 50th where I met them for the first time. His resume shows the following professional activities: 1929-1936, assistant to the president of Dewey and Almy Chemical Co; 1936-1976, president, Slagle's, Inc. (food related business); 1941-1945, (World War II years) C.W.S. development laboratory at M.I.T. His hobbies include tennis (Winchester Country Club), gardening and travel (most of the winter in the Caribbean.) Slagles list three children and nine grandchildren. . . . **J. Wesley Walters** writes, "Thank you very much for the birthday greetings that I have been getting from the Class of 1929 for many years, even though I remain 39. Thank you also for all the work you have done as our class secretary, and will continue doing it for the next five years, according to the nominating committee report. I regret we did not make it to the 50th Reunion, but my thoughts were with you. My wife Josephine and I finally prepared and celebrated our 50th wedding anniversary on June 27, followed by an open house arrangement by our son and daughter and their families on July 1. I extend greetings and best wishes and happiness to all the members of the class of 1929 and all my other friends of 'Tech Days' for the years ahead." Wes graduated from Course I (civil engineering) and spent all of his professional career with the U.S. Corps of Engineers, St. Paul District, until his retirement in 1965. He was the area engineer on projects in northern Minnesota and Dakotas for eight years, he was on special studies, war projects and in charge of reservoir projects in the district for ten years. He was in operations in charge of all structures in the district in charge of 175 men for ten more years, during which ten Mississippi River navigation locks were rehabilitated. Their hobbies are travel and sports. Their travels have included all the 50 states including Canada and most of the European countries. Wes was instrumental in initiating an "annual" reunion of former and present Corps of Engineers employees in 1975. The idea was well received, which has now become an ongoing event.

Walter Partridge has sent a "Thank you" note for the birthday greeting he received from the Class of 1929. Walter was present at the 50th Reunion with his wife Dorothy. Professionally, he is a Course I (mechanical engineering) graduate and as such, he was associated with the U.S.M. Corps, chemical division, in Cambridge, Mass. He was a plant engineer and design engineer in the Cambridge plant and engineering manager for all the plants in the U.S. and Canada. His hobbies are travel, memberships in various organizations and sports. He is treasurer and director of Andover Historical Society, deacon, trustee, and auditor of Andover South Church and trustee of Andover Home for the Aged.

I regret to announce the death of **James N. Latimer** on September 11, 1978. His career was mostly in the uranium field, as an ore-buying contractor for the American Smelting and Refining Co. and U.S. government's raw materials procurement program. His responsibilities included organizing the early operations and establishment of an analytical laboratory which sampled millions of tons of ore. He established and operated 12 additional plants through the years, and pioneered in the design of such plants as well as the equipment. — **Karnig S. Dinjian**, Secretary, P.O. Box 83, Arlington, MA 02174 (617) 643-8364; also 10 Ancient Highway, Plaice Cove, Hampton, NH 03842 (603) 926-5363

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Please accept my apologies for the lack of Notes in the October issue. The preparation of the October Notes was delayed because of lack of material, and by the time sufficient material had accumulated, the deadline for the October issue had gone by.

Those of you who attended the 45th Reunion will recall that as of that time Betty and **Ed Kingsley** had recently bought a condominium at Leisure World in Mesa, Ariz., (near Phoenix) as a winter home. Ed writes that while they are still spending their winters in Mesa, they have sold their home in Wellesley and have bought a condominium at Royal Crest Country Club in Walpole where they will spend the summer months. Ed says the condo in Mesa is delightful and that they would hate to dispose of it, but the summer temperature makes outdoor activities almost impossible from mid-June to mid-September. Ed still owns his contract carpet and drapery business but now has an associate who does most of the work. He reports that several years ago **Bob Nelson** and his wife visited the Kingsleys in Arizona, and they played tennis together. He and Betty are looking forward to the 50th Reunion at Chatham Bars.

As previously reported in the Notes, **Henry O. (Pat) Pattison** and his wife Mary retired to Tucson, Ariz., in 1970. They have a summer home in Pebble Beach, Calif., to get away from 100+ summer temperatures in Tucson. Pat has maintained his interest in amateur radio and keeps in daily touch with friends all over the world. Pat says that he and Mary will be coming East in October for their 50th wedding anniversary party, and he thinks that one 50th-year celebration will be enough for them. However, it seems that Mary has begun to talk about attending her 50th Reunion at Wellesley, and hence they may possibly change their minds and take in the 50th at M.I.T.

Pat reports that their four sons "are all doing very well in the business world" and have produced a total of ten grandchildren. The No. 1 son Bill graduated Phi Beta Kappa from Rutgers and is now senior vice president of Ogily Advertising. Peter graduated from Yale and is now president of Peter Pattison Assoc., listed as one of the largest U.S. real estate companies. Michael is also a Yale man and is a broker with Blythe, Eastman, Dillon in Colorado Springs. Bob (Dr. Robert Pattison), another Yale man, is a professor at Southampton College and author of many books on the English language. In addition to his Yale degree, he has an M.A. from the University of Sussex and a Ph.D. from Columbia.

Dick Ogden reports that he retired in 1967 but doesn't say from what. He and his wife Isabel are currently living in Corpus Christi, Tex. The Ogdens have a son David who is with Stewart-Warner Corp. in Indianapolis, and a daughter Peggy who is now a housewife in San Marcos, Tex.

As previously reported in the Notes, **Willard Paine** retired as board chairman of the Bendix-Westinghouse Automatic Airbrake Co. in 1970 and moved to La Jolla, Calif., where he and his wife are still living. The Paines have a daughter Caroline, a son Willard and six grandchildren.

Last week **Bob McCarron**'s son called to tell me that his father had died on July 19 after a long illness. I may say that this news brought back memories of the time that Bob and I spent at the Chemical Engineering Practice School stations in Bangor, Maine and Buffalo, N.Y. As many of you know, Bob spent most of his working life in the paper business. After completing a thesis with your secretary and graduating from M.I.T., Bob went to work initially for Kimberly Clark Corp. and thereafter worked for Consolidated Papers, Stevens Point, Wis.; Escanable Paper Co. (now Mead Corp.) in Escanaba, Mich.; Stein Hall and Co., Inc.; and Morningstar Paisley Inc., which was ultimately acquired by A. E. Staley Co. He became technical service manager of Morningstar in 1964 and sales manager in 1968, from which he retired. Over the years I used to see him from time to time at the T.A.P.P.I. meetings in New York. His hobby was the history of papermaking and early printing and engraving. In addition to his wife Winifred, he is survived by three children: a son Bob who lives in Clinton, Conn.; a daughter Virginia who lives in Merrimack, N.H.; and younger son Paul who works for Hercules Inc. and lives in Belgrade Lakes, Maine. — **Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, NY 10036

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For some time now, I have been keeping a ham radio schedule with **Fred Elser** — and at long last he has sent me a photo of Mardi and him in Honolulu where he lives. Fred is now working on his doctorate and should be getting it in the not-too-distant future. Another Fred, **Fred Jelen**, was recently awarded a life membership in the American Association of Cost Engineers, the 13th recipient since the association was founded in 1956. Congratulations!

Thanks again to our assistant secretary, **John Swanton**, I am able to report the following: **Art Bertolett** has two children and seven grandchildren. He is retired and enjoys boating, travel, and yard care and is active in church work, the Masons, and S.A.R. **Ed Blake** has one child and two grandchildren, is also retired, likes painting, golf, and sailing, and spends seven months in Jaffrey Center, N.H., and five months in Englewood, Fla., each year. **Bowman Cutter** has two children and three grandchildren, is retired, and has been married for 41 years. He has many hobbies, including travel. **Frank Dame** has two children and five grandchildren, is retired, and has been widowed since his wife died on January 25, 1977, after a long illness. He lives in an apartment but has a large garden of flowers and trees in Winter Park, Fla. **Warren Dickinson** is also retired and likes flying, golfing, and travel. **Victor Duplin** has five children, 14 grandchildren, and one great-grandchild. He was widowed in 1956, remarried in 1958, and likes farming in Roanoke, Va. **John Dyer** (another radio ham) has three children, says he is "so-called" retired — almost forgot he has seven grandchildren, likes gardening, metal enameling, music, woodwork and working in his greenhouse. Another retiree is **Fred Eaton**, who has two children and four grandchildren and likes golf and bowling. **Cliff Harvey** (also a radio ham) is retired, has two children and six grandchildren, and resides in Sturbridge, Mass. **Charles Martel** has two children, is retired from Raytheon after 39 years and now has a part-time business in electronics; he spends summers in his lake-side cottage in New Hampshire. **Ted Morrill**, also retired, says his hobby this year has been cleaning up woods after the January storm damage. He lives in Ashfield, Mass. and enjoyed, as did we all, the mini-reunion in Bermuda. **Myrle Perkins** is 95 percent retired, has two children and five grandchildren, and is trying to become accustomed to California living. **Enio Persion**, who also attended the mini-reunion, has two children and five grandchildren after 46 years of marriage to his wife Loretta. He is still working, likes to travel, but was slowed down in November with a heart attack. **Joe Pasell** (seven children) retired from Vermont American Corp. in 1973 but went back to full-time teaching at Martin Community College in 1977. His new address is Rt. 2, Box 120, Washington, N.C., 27889. **Bob Price** is 50 percent retired and a widower. **Leslie Reed** has four children, is 75 percent retired, is a widower and lives alone. **Cliff Smith**, retired, has two children and four grandchildren. He likes boating in the Florida waterways and traveling, having been to Majorca, New England, Nova Scotia, the Orient, the West Coast and Banff, as well as on Caribbean cruises. **Art Sugden**, also 95 percent retired, has two children and one grandchild, likes traveling and gardening. **Francis Weeks** has three children and seven grandchildren, is retired and travels in connection with his professional activity in colored slide showings and furnishing copy-slides to museums. **Joe Brennan**, father of two children and three grandchildren, reports that he is 90 percent retired and spends 10 percent of his time consulting; he travels both in the USA and abroad. Joe's career was principally with the Corps of Engineers and on the Public Works Committee in the U.S. House of Representatives. **Angel Silva** reported from San Juan that he is still "active." **John Tillinghast** is a widower and his main hobby is sailing although **Larry Barnard** frequently sees him strolling on the beach in Florida. **Al Sims**, 100 percent retired, has five grandchildren, has remarried, likes gardening, bridge, and some travel, and is also a "train" nut. — **Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, FL 32757; **John Swanton, Jr.**, Assistant Secretary, 17 George St., Newton, MA 02158; **Ben W. Steverman**, Assistant Secretary, 3 Pawtucket Rd., Plymouth, MA 02360

32

Here are the results of the first (and maybe the last) annual Class of 1932 golf tournament:

	Gross	Handicap	Net
Elton V. Buckley	77	15	62
Don Brookfield	89	18	71
Melvin Castleman	100	27	73
John W. Flatley	80	14	66
William B. Pearce	94	24	70
Richard H. Stewart	88	21	67

First prize for low gross and low net goes to Elton Buckley; second prize goes to John Flatley. Congratulations! A suitable certificate will be forwarded to you. I must say I expected a better response from our class. Oh, well!

Along with his score **Elton V. Buckley** sends a letter saying he is enjoying his retirement. His wife and he do much traveling up and down the East Coast visiting friends and family. Landscaping, pinochle, and golf are his main hobbies.

Dick Stewart says he has retired twice; once, as President of Anaconda American Brass and once as Commissioner of Commerce for Connecticut. Now he can devote more time to his hobbies; one is golf, which is most frustrating, and the other is the restoration of antique cars. He devotes considerable time to his church.

Russell S. Robinson writes that he just returned from another cruise in the Gulf of California — the second this year in his sailboat.

Herbert F. Ross and his wife are living the good retired life after many years of work. They spend seven months of the year in Naples, Fla., and five months at Osterville on Cape Cod, Mass. Herb plays golf the year around — and often with M.I.T. men. He keeps busy as president of a cooperative in Naples, serves on golf and community committees, spends his time on his boat chasing Wiley Bluefish. Herb and his wife enjoy entertaining their five grandchildren.

Earl F. Anderton has finally retired from a good 44-year career with the Scott Paper Co. with which he has had many interesting and rewarding assignments. He is now president of the North American subsidiary of a Finnish engineering company. They engage in many international activities — all centering on energy.

Robert I. Phemister reports that he is alive and well and living in Sun City, Ariz., with his wife. He plays a little golf, does cabinet work and wood carving. He also serves as a volunteer at the local hospital.

John Lawrence retired from Dresser Industries on February 29, 1976 — founded J. Lawrence, Inc., a management and investment consulting firm the next day, March 1, 1976. . . . **Bruno Werra** is the engineering service manager of Ladish Co. Tri-Clover at Kenosha, Wisc. 53141. . . . **A. L. MacKusick** writes amusingly, "slowed up recently by a little surgical 'repairs' on my 'innertubing,' will be back at full steam soon."

Frank S. Chaplin and his wife attended the M.I.T. Fiesta in Mexico in March where they had a Class of 1932 mini-reunion with the **Joe Frenches** and the **Russell Robinsons**. Frank is still doing some consulting work and trying to finish his home in North Carolina.

We have received the sad news that **Daniel P. Dyer, Jr.** died on June 18, 1979. Our class wishes to express our sympathy to the family.

Keep writing. Sincerely — **Melvin Castleman**, Secretary, 163 Beach Bluff Ave., Swampscott, MA 01907

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Headlines this time go to one of our distinguished architects, **Tom Fitzpatrick**, whose fine letter I will quote: "We now live here (Highlands, N.C.) ten months of the year and return to Skidway Island, Savannah, for January and February. When we travel, it is either in the winter or late fall. We were up in Whitefield, N.H., a summer ago, and almost got in a side trip to Exeter. (Now he tells me.) I still do occasional consulting work in architecture but don't let it interfere with tennis or other fun. Two years ago, Beverley and I spent two months of the winter in Cassis, France, about 30 miles east of Marseilles. It is a small fishing village on the coast, and most charming: no English spoken, so we had to move over into French. It was fun, and we enjoyed moving in the life style of the village. We love the South of France, revisiting old haunts. Last winter, we took a cruise on the *Viking Star* through the Mediterranean into Russia, Turkey, the Greek Islands, and Malta. Returning, we found entering the Port of New York to be a disaster. The way we were treated by the port officials and stevedores was disgraceful. I don't know how our foreign visitors react, but, as an American I was dismayed. I will avoid the 'Big Apple' in the future. I see **Munroe (Dizzy) Labouisse** from New Orleans, who was with us in architecture but did not finish with us. He is also semi-retired but will be remembered by many of our classmates. We had two new grandchildren last December, and another is due shortly. They are all a great joy. We are both disgustingly healthy, with only minor ailments resulting from the aging process. We are sorry that we could not make the last reunion. Some crisis always seems to interfere." Fellas, the above letter from Tom omits the fact that he is, and has been, one of our more distinguished classmates; he was literally the founder of the School of Architecture at the University of Virginia and its dean for many years.

Cal Mohr has more information on **Art Mason**, whose death was reported here but with no details. With the Northwestern Mutual Life Insurance Co., Art concentrated on owners and partners in business. Some time ago Art was confined to a wheel chair following a severe stroke. Art was married and his wife survives him, as well as a son and a daughter. Cal asks if any Andover men attended their 50th Reunion, as **Walt Duncan** did his at Exeter. No, Cal, none made it.

We have a fine letter from **Ellis C. Littmann**: he cannot attend the coming Alumni Officers' Conference, because he has to be in Cambridge for a visiting committee and a Corporation meeting the next week, and it is apparent that he cannot spend that much time away from business. Ellis promises to write again soon to bring me up to date on his recent activities.

At a time of news drought, we do have three Alumni Fund capsules, and they are always welcome: Golly, we hadn't heard from **Morris Guralnick** in a long time, but here he comes through. Morris says that he was recently elected

chairman of the board of the Morris Guralnick Associates, Inc., in marine engineering (he omits that the firm is also well known as ship designers, and he himself is a marine designer of distinction). **Bill Conant** comes through with a very acceptable message: he is still in his retirement, enjoying golfing, gardening, and bridge, finding the house and yard far too big for their present purposes.

Most fortunately, there have been no reports of demises to reach this column, and it is to be hoped that the trend stays that way. Perhaps some of you will note that this report is far too short, and I can assure you that were it not for Tom Fitzpatrick's letter, I would not have written at all, for November. I'd be too ashamed: nuff sed. — **Warren J. Henderson**, Secretary, Fort Rock Farm, Drawer H, Exeter, NH 03833

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This month the input is rather slim, so the output will be likewise — mostly Alumni Fund notes. However, they are not quite so cryptic as some in the past.

From **John W. King** in Rockford, Ill., comes a note that shows he is still hard at it. He says: "In my 70th year I find myself merrily farming and so forth, the same as always, with nary a thought about growing old and retiring. The August or September issue of *Prevention Magazine* will have an article about some of my ideas on organic farming and health in their long distance feature. It will be valuable reading, especially for those who keep telling themselves they are sick or growing old."

One who has retired is **William T. Barry, Jr.**, who writes: "I retired from the Trust Department of the State Street Bank and Trust Co. in April of 1976 and am now keeping busy on the home front. I was elected commander of the American Legion Post 35 and lecturer of Ocean Side Grange No. 260. Both organizations are here in Hampton, N.H. Gardening and oil painting take up the slack."

Over the years I remember that **Jerry Raphael** has been very faithful in sending notes on what he has been doing in his specialization in reinforced concrete structures, including building his own ferro-concrete sailboat. As you can see from his latest one, he is now following the classical professorial route — retirement, but still keeping a finger in the pie. He says: "I retired just now from the University of California, Berkeley and am now emeritus professor on recall to teach one course each year. I am also consulting engineer on the El Cajon Dam (about the size of Boulder Dam) in Honduras. I am still winning my share of races in 'Sprite.' "

I had a slightly apologetic note from **Walt Wrigley**, saying that he couldn't come to the Alumni Officers' Conference because he and Dorothy were going to Europe. I answered that it was great that he was apparently so completely recovered from his hip operations that he could make the trip; that I didn't see that he owed me any explanation; but since he seemed to feel so, his penance would be some words about his trip when they get back. We shall see how he honors my demand! — **Robert M. Franklin**, Secretary, 620 Satucket Rd. (P.O. Box 1147), Brewster, MA 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Apt. 711, Chevy Chase, MD 20015

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Walter H. Stockmayer is retiring after 18 years from his chemistry professorship at Dartmouth College; but he'll continue on a two-thirds-load basis for at least two more years during which time he will be professor emeritus. Along with teaching, he has been conducting research into the physical chemistry of large molecules and has received world-wide recognition for several of his published results. The National Science Foundation recently renewed his grant for another three years. . . . **Allen Beckwith**, professor of marketing at Boston University, was elected a director of Almy Stores, Inc.

Dedicating the Frank R. Milliken Mine. When Ozark Lead Co., Kennecott Copper Corp.'s subsidiary, starting looking for lead in the Missouri hills in the early 1960s, it optioned 176,000 acres and sank 29 drill holes before making its significant find; by 1981 some 15 per cent of U.S. lead ore production will come from this one mine. But the trend to withdraw public lands from such exploration might have foreclosed this discovery today, said Mr. Milliken at ceremonies last summer — "a persistent campaign in Washington" to bar public lands to minerals exploration without considering "the future health of the national economy." With Mr. Milliken — he studied mining engineering with the Class of 1934 at M.I.T. — at the dedication were Harold A. Krueger (center), general manager of Ozark Lead Co., and Thomas D. Barrow, chairman of Kennecott's Board of Directors.

A Warning on Public Lands on Milliken Day in Missouri

Since 1968 Ozark Lead Co., a subsidiary of Kennecott Copper Corp., has been mining lead and zinc in Sweetwater, Mo., with great success: from an average of 1.5 million tons of ore annually have come 68,000 tons of copper, 7,500 tons of zinc, and lesser amounts of copper, silver, and cadmium.

Now the mine is being expanded to produce 33 per cent more ore, and it's been named in honor of **Frank R. Milliken**, '34, who retired late last year as chairman and chief executive officer of Kennecott Copper Corp. after a 27-year career with the company.

The original mine was conceived in the early 1960s by Mr. Milliken "in the finest mining tradition," said Thomas D. Barrow, chairman of Kennecott Copper Corp., at dedication ceremonies on August 2. "More than any other project of the corporation, this mine bears his personal stamp."

By proclamation of the governor, it was Frank R. Milliken Day in Missouri.

After apologizing to his audience for doing so, Mr. Milliken took the occasion of the dedication to speak "in furtherance of a personal cause": his dismay at "the present trend in Washington to arbitrarily lock up, earmark or allocate public lands . . . without full consideration of how those lands might be used in the best interests of the American public.

"The most blatant part of the federal campaign," he said, "has been the withdrawal of lands from *any* practical use . . . recreation, timber development, roadbuilding, mineral exploration. . . .

"Restrictions on exploration now raise a real danger that we could find ourselves in the same fix with regard to many hard minerals after the turn of the century as we now face with regard to oil," Mr. Milliken said.

Through the Alumni Fund office we have received the following notes: from **Philip H. Rhodes**, "Still employed as technical director at Custom Coated Products in Cincinnati and having a ball." . . . from **John S. Holley**, "Wine isn't the only thing to improve with age — likewise my power to procrastinate. Fully retired means more time to do nothing. I'm so busy doing that, I can't plan what not to do tomorrow. Terrible! Our health is good. My 100-square-foot farm is producing like mad. San Diego weather stays beautiful as do the women. Mexican gas is $0.4696 and no lines."

More plans are being generated by **Bernie Nelson**, class president, for our 45th reunion next June. **Henry F. King** is chairman of the Cape Cod part of our reunion at the Wianno Club and Edward J. Collins of the M.I.T. Cambridge part starting with Pops. Save the dates from June 5th through 8th and plan now to arrange to attend.

I am sorry to announce the death of another of our former classmates: **Joseph L. H. Kemper** in Cincinnati in April.

A week ago **Bob Flood** was referee and host to a match between **Goffe Benson**, **Les Brooks**, and your secretary to determine the Cardinal Flight Golf Champion. We played at Bob's course at the Winged Foot Golf Club and had a great time. Les Brooks won by playing steady, deliberate golf; he beat Goffe and me by 11 strokes, and he now goes on to play the winner of the Grey Consolation Flight. Next notes will tell you how it all came out. As this is being written, **Mort Rosenbaum**, **Gerry Rich**, and **Sid Grazi** are playing in California at La Costa to determine the Grey Flight winner.

Now that summer is over, how about dropping me a line? That goes especially to those of you who are tired of all the golf news. — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, MA 02160

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With his contribution to the Alumni Fund, one **W. Boynton Beckwith** reports (and I quote in its entirety) "Now retired in San Diego — both of us. Will send more details to Alice later." Well, I do hope that either he or Virginia will follow up on that promise. I will share with you any information I receive! . . . In the last issue I reported the death of **Henry Christensen**. Louise has sent me some clippings with more information and I wish to share some of it with you. Henry was not very communicative as far as the class was concerned so some of you may not know much about him. Until the early 1950s he conducted a successful institutional laundry business. However, his longtime and growing hobbyist's passion for coins — focused at the beginning on Scandinavia — led him to dispose of the business to his best customer, the Waldorf Astoria, and turn to numismatics as a professional. The firm of Henry Christensen, Inc. was established with headquarters in Hoboken and eventually moved to Madison (New Jersey). In 1964 William B. Christensen (Bill) joined his father and Louise has long been a silent partner. They are carrying on the business. In addition to Louise and Bill, Henry is survived by another son, a daughter, and four grandchildren. Henry also enjoyed tournament bridge at the New York Ahtletic Club — **Alice H. Kimball**, Secretary, P. O. Box 31, West Hartland, CT 06091

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Frank Lewis of Lexington, Mass., has a "retirement job" at Caywood Electronics, Inc., of Malden, Mass. He is still a member of Study Group (Standard Time and Frequency) CCIR, a government committee. In November, 1978, he had a total left hip replacement (osteoarthritis). On September 5, 1979, he had the right hip done in Mt. Auburn Hospital, Cambridge. At the time we went to press, he was just out of intensive care and his condition was good. We hope his recovery is rapid. His wife, Mary, recovered from a ruptured appendix in October, 1978. Their daughter Patricia plans to graduate in 1980 from a medical records administration course at Northeastern University and their son Robert (Carnegie-Mellon, 1974) is now with Abt Associates, Cambridge, Mass. Their son Peter (M.I.T. '75) is "chasing a biology Ph.D. at Yale." Frank and Mary hope to be able to travel after their daughter graduates in 1980.

It is with regret that we learned from **Frank Lewis** that **Louis Laforge**, San Mateo, Calif., died on April 17, 1978, from heart failure and **Don Kerr** died of cancer in 1976. In addition, I regret to report the death of **Jean R. Portelance** at St. Sauver, Quebec, Canada, on July 14, 1979.

George M. Levy, of Newton Center, Mass., writes he is still president of Chaudler-Levy Hardware, Inc., is a "golf bum" and loves the game though he claims he plays poorly. He is in good health, continues to serve on the board of the Newton-Needham Chamber of Commerce, and is president of the Newton Center Improvement Association. His wife is sales manager of H.B. Sales, account executive of Miliken and president of the Newton Center Association for Commerce. Their daughter — Jane Ellen Reid, mother of their grandson James — is on the way to Bali with her husband to do a documentary on the music and customs of the people; their second daughter, Nancy Ruth Levy, who teaches Spanish at Boston College and Wellesley College, wrote a paper on "Methodology of Teaching Foreign Languages."

Charles Dierksmier, of Wilton N.H., retired on his birthday, August 7, 1979, from Abbott Machine Co., Inc., of Wilton, N.H. He was plant manager and a director. He worked there for the last 34 years. Charles plans to spend summers on Cape Cod, spring and fall months in N.H., and winters in Florida. He feels great. . . . **Jack Simpson** writes that he "lost a lung" and has been a little under the weather. We hope his convalescence is smooth and his recovery fast. . . . **Albrecht L. Reinhardt** retired in July, 1979, after 27 years with Hamilton Standard Division of United Technology Corp., where he served in various engineering capacities, including Chief Engineer for Aircraft Environmental Control Systems. His oldest daughter Diane (32) received her Ph.D. from Stanford in '72; his youngest daughter Rochelle (20) graduated from Yale in May '79. . . . **Robert N. Cornforth** retired in May from H.K. Ferguson, and in June joined Process Plants, Inc., a Houston-based constructor of petroleum and chemical plants, as Director of Marketing. . . . **Michael Zinchuk**, still with Polaroid Corp., is planning to retire soon to Hyannis on Cape Cod. — **Lester H. Klashman**, Assistant Secretary, 198 Maple St., Malden, MA 02148; **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, MA 02155

38

This summer **Yale Brozen**, who is a professor of business economics at the University of Chicago, wrote an article for the *New York Times*, entitled "Six Lies on Energy." He points out that proven reserves of oil are at an all-time high; that if government would let the private sector do its thing and would stop deficit spending, energy would be far more plentiful — an article well worth reading.

Eric Thrift writes that, while he has officially retired from the faculty of Queens University at Kingston, Canada, he is still conducting several courses in the Graduate School of Urban and Regional Planning.

Regretfully, I must report the deaths of **John Doremus** and **Howie Schlansker**. — **A. L. Bruneau, Jr.**, Secretary, 663 Riverview Dr., Chatham, MA 02633

39

Today I was carried away by an educational TV broadcast of Al Hirt and Pete Fountain who received standing ovations during their jazz concerts last summer at Wolf Trap. Knowing **Aaron White** was another jazz buff, I phoned to suggest he catch the rerun. But Whitey said he and Edith heard this great program the night before from their home in Waban. Small world!

Evan Pancake retired in Bellaire, Texas after 40 years with Texas. He and Dee propose a cruise thru the Carribean, Panama Canal and the Pacific. . . . **Bob Stone** retired from his high-flying career with United Airlines and relaxes these days on Florida's southwest suncoast. . . . **Nelson Bogart** retired and majors these days in sailing from his cabin at a lakeshore near Tahoe. . . . **Collin Alexander** travels on the international circuit where he consults on thin films using sputtering and evaporative processes in high vacuum atmospheres. . . . **Don Leslie** retired after 33 years with Braun Engineering and enjoys a new home located near Maisie and Bob Fife ('40), at Aptos, California.

My report on 40th reunion inadvertently omitted mention that selection of the great site was a project shared by **Seymour Sheinkopf**, **Ernie Kaswell**, **Fred Schaller**, and **Aaron White**. **Irv Peskoe** was the guiding force and chief holder of the broom for both the class questionnaire and its consolidation into " '39 and going on our 40th."

After reunion, **George Cremer** and Billie spent three months on the East Coast and then brought George's mom from her central Park apartment to live here in the garden spot of the universe. By the time you read these notes the frost will have been on the pumpkin in New England, and you can all think back to two months before when Grandma Cremer was enjoying her daily swim in George's pool. I wonder how many of us, twenty years from now when we get to be Grandma Cremer's age, will enjoy a daily swim in pools of our sons and daughters. — **Hal Seykota**, Secretary, 1421 Calle Altura, La Jolla, CA 92037

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Thirty. **Winfield H. James** retired June 1 as president, publisher, and chief executive officer of the *New York Daily News*. He started with the *News* in 1940 and became its publisher in 1973.

Apres-Work. **Marshall D. McCuen**, with General Motors until two years ago, lives on in Indianapolis, close to squash, racquetball, golf and sailing, volunteering there for Republican efforts and the United Way, but breaking the routine with ski trips to the far West.

Steel and Song. **Roger F. Mather**, out of metallurgy in 1940, has metamorphosed as an adjunct professor of music at the University of Iowa's School of Music.

Balance of Payments. **Oliver H. Fulton** is the executive director of Maryland Industrial Development in Baltimore's World Trade Center and is presently the president of the M.I.T. Alumni Club of Maryland.

Another Way to Fly. In from Dallas, **John J. Casey**, Braniff's board vice-chairman, announced a big new terminal facility for his airline at Boston's Logan. He has an eye on Braniff's expanding international system.

In Memory. Ethel Cohen has written to tell us of her husband's death, July 25. **Samuel L. Cohen** just last year agreed to edit the 1940 Class Book for our 40th Reunion, following his retirement from the Naval Research Laboratory in Washington, D.C. She says, "Because we believed this would have made Sam very happy, we noted in various obituaries about him, contributions could be made to the Class of 1940 40th Reunion Fund." The Alumni Fund office has already received several memorials.

Recall Department. **James L. Baird**, 705 Sycamore Lane, Wilmington, Del. 19807, has agreed to be editor of our 40th Class Book in place of Sam Cohen. Jim plans to distribute a questionnaire to all '40 graduates as primary material for the book. Help him with prompt answers.

Octoberfest. Our next issue will carry all the results from the October 12-14 reunion planning session in Hershey, Penn. The interest which **Norm Klivans** has tapped is shown by the list of "I'll be there's," including: **Richard C. Babish**, **Donald G. Bry**, **Richard Braunlich**, **Bruce Duffett**, **Maurice E. Flynn, Jr.**, **David R. Goodman**, **Robert A. Grosselfinger**, **Frederic W. Hammesfahr**, **Joseph C. Jefferds, Jr.**, **John L. Joseph**, **Louis V.**

Russoniello, and **M. Spalding Toon**.

Further Details. If you'd like to work with **John L. Danforth** on the Cambridge and Cape weekend (June 4-8, 1980) write Jack at 35 Farm Lane, Westwood, MA 02090. **Norm Klivans** needs more help to get the class gift together. Write to him at 14731 County Line Rd., Chagrin Falls, OH 44022. — **Frank A. Yett**, Secretary, 1405 Ptarmigan Dr., Walnut Creek, CA 04595

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First, congratulations to **Curt Buford**, President of Trailer Train Co., who was named a director of Allegheny Corp., and to **Carl Meurk**, who has been elected a vice president of Todd Shipyard Corp.

Heinie Shaw writes that he is still an active member of the National Ski Patrol System. He completed 37 days of skiing during the past season but his last weekend on the mountain was the third week in May. Things are tough all over! In any case, Heinie certainly gets first prize as the Class' No. 1 skier. . . . We have a status report from **George Watters**: he is still president and chief executive of Singapore Petroleum Co., which is the largest independent refiner and marketer of petroleum in the Far East. His oldest son Kent owns an export business in Indonesia, and apparently his oldest daughter Heather is export manager of the firm. The rest of the family, young David and Lisa, are still in school. . . . **Lin Adams** came through with a status report; this fall he will have three daughters in college. Last year there were only two. The fourth of the Adams tribe is still in high school. . . . Pat and **Dave Lambert** sailed their Cal-25 to victory in the recent Boyd-Lareau Trophy Regatta.

While on the subject of boats, **Jon Noyes** recently won a $15,000 23-foot Columbia sailboat by estimating Whittaker Corp's (they own Columbia Yacht) sales volume and income. The Noyes now have a 19-foot power boat parked beside their house, and so I guess the yard is getting a little crowded. Anyway, Jon is probably the only one of our class members who owns both a 19-footer (powered) and a 23-foot sailboat. If anyone is looking for a ride, I suggest they get in touch with him in Corpus Christi (Tex.).

One obit this month: **Mark Kravitz** of Manchester, Conn. died while on vacation in Canada early in August. Mark was very active in all of the communal affairs in the Manchester area. He was associated with the Connecticut Shade Tobacco Growers Association starting in 1953, and retired as executive director of the Association in 1972. Mark then switched careers and founded the Steak Club Restaurants. Our sincerest condolences to Marjorie and to the family. — **Ken Rosett**, Secretary, 191 Albemarle Rd., White Plains, NY 10605

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Robert H. Scanlan, who received his doctorate with our class and who has been a professor in the department of civil engineering at Princeton since 1966, is the co-author of two recent books: *Wind Effects on Structures*, (Wiley, 1978) with Emil Simiu, and *A Modern Course in Aeroelasticity*, (Nordhoff, 1979) with Earl Dowell *et al*. Professor Scanlan's technical interests have included vibrations, structural dynamics and the wind loadings of structures. . . . **Gus Root** has become executive assistant to the president of Johnson State College in Vermont. He wrote that "I followed my wife on this, our most recent move, and have been delighted with rural Vermont and a new administrative position."

John Gardner wrote that he retired from Exxon on April 1, 1979, and that he had enjoyed his last two years in Nairobi, Kenya. . . . **Chris Matthew**, as chairman of the Alumni Fund Board, will have spent three busy days at the Alumni Officers' Conference late in September by the time these notes are published. Chris has always been a leader in alumni activities, and we sure should rally to his causes when our annual gift is made. — **Dick Feingold**, Secretary, 799 Prospect Ave., West Hartford, CT 06105

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May we wish you all a Happy Thanksgiving and hope you get to read these notes in the *Review* before then.

Thomas Lawson

The Alumni Office has sent us a notice of the elevation of one of our classmates at Xerox. **J. Thomas Lawson** achieved the presidency of XTEN Services in May. (XTEN is part of the Xerox Development Corporation.) Tom had previously held senior executive posts at I.B.M. and G.T.E. and had been a general management consultant to Xerox. In his new position, at Tarzana in California, Tom will be furthering a new high-speed communication system for the transmission of documents and data and for teleconferencing. (We hope he doesn't apply the new system to reunions; we'd like to have him attend in person. We have included a recent photo of Tom for your benefit.)

Flap Facts. **Bob (Robert H.) Wood** and Alison enjoyed their visit to Cambridge for our 35th Reunion banquet renewing old friendships. . . . **Al MacLean** writes of his regret that his business schedule kept him away from the 35th. He has better hopes for the 40th. (We'll start planning earlier, Al — like right now!)

Tom Carmody (one of the great reunioners of all time!) sent in a flap and also his business card (which we ask you all for; see below). Tom is applying chemical engineering and a lot of experience to the improvement of "occupational health." To paraphrase his statement: "After all the others have talked about a problem, it turns out the engineer is the only one who can and will solve it."

From Venezuela **Joe Aguila** writes that he enjoyed the 35th Reunion thanks to the Sebells and the committee.

William M. Heyser sends a note as a member of '47. The Alumni Association lists him as Class of '44, and a check of the *Technique* shows him as a member of the original Class of '44. We hereby extend a welcome to Bill into the Class of '44. We're sorry you missed our 35th Reunion. If you want to join '47's next quinquennial, fine. But please plan on refreshing old acquaintances and making new ones at our 40th — in 1984.

At the 35th, Melissa asked classmates to send in information on their working activities. There is obviously a wealth of talent from our class out there in the business, academic, and government world, and it might be very useful (as well as interesting) to know what influence our class has had and how many of our classmates and/or their spouses own, operate or head up their organizations. The first mailing of the business card directory will be sent to those who attended the 35th in Bermuda. From time to time we hope to send additional mailings to all who send us a card.

We are continually adding to our savings plan for our next class event in Mexico in 1981 — "fiesta time." Do join us. — **Melissa and Newton Teixeira**, Co-Secretaries, 92 Webster Park, West Newton, MA 02165

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(Continued from last month.) Brian didn't go into the jungle *on foot* to look for the pyramids after all. Actually, he went on his own jungle expedition by helicopter (with only 25 kilometers on foot) to photograph Indians on a rubber plantation. He called from a little jungle village when he got out, using the only phone in town, which was in service from 7 a.m. to 7 p.m. Three hours later he called from Brasilia; then in a few hours he was in Rio. Brazil has a large small-aircraft industry, since much of the country is accessible only by air.

N.A.S.A. and the U.S. Department of the Interior have honored **Ginger Tower Norwood** of our own aircraft industry with one of the two William T. Pecora Awards this year, given for outstanding contributions in the field of remote sensing. Ginger's work was in systems design and engineering for the Hughes Aircraft Co. Multispectral Scanner (MSS) and Thematic Mapper (TM). She has been working on a variety of space- and space-related projects in the almost 25 years she has been with Hughes, including *Surveyor* (the transmitter), the *Syncom* communications satellites (the microwave system), and the large antenna arrays for the Super Constellation and B-58 aircraft. Ginger says MSS has been the most satisfying of her projects at Hughes, and is quoted in *Hughesnews*: "It has been a real thrill to have the opportunity to meet the hydrologists, the agronomists, the geologists — the people who use the MSS data." MSS is used on board the first three *Landsat* satellites, and TM (with even better resolution) will be on *Landsat 4* to explore and monitor Earth's resources from space. Ginger is currently in Culver City, in the Electro-Optical and Data Systems Group's Strategic Systems Division.

Hal Raiklen reports that in July he was appointed vice president of strategic aircraft and systems at the North American Aircraft Division of Rockwell International, after 7 1/2 years as vice president of research and engineering. In August he received the Aircraft Design Award from the American Institute of Aeronautics and Astronautics, an award presented annually "for the conception, definition, or development of an original concept leading to a significant advancement in aircraft design or design technology." Hal's contribution was in "knowledge, dedication, perseverance, and leadership with which (he) integrated diverse technical requirements and concepts to bring about the successful design and development of the B-1 strategic aircraft system." Hal acknowledged the award on behalf of the members of the B-1 design team, and accepted it as their representative. Hal is also a recipient of the N.A.S.A. Public Service Award, a member of the Division Advisory Group of the Air Force (D.A.G.), and is on the board of directors of the American National Metric Council and the Executive Advisory Committee of the Society of Hispanic Professional Engineers. Other positions at Rockwell include director of electronic and electrical systems on the XB-70 program, vice president and program manager on the Saturn V Stage II launch vehicle, and vice president of research and engineering at the Space Division. Hal is in Los Angeles now, though he had to come East to accept his award. He allowed as how he might even venture east of New York City (could he mean Boston? Long Island? Paris?)

And yet another aircraft crafter: **Dan Carnese**, at Sikorski, is now head of the aeromechanics and structures branch. Daughter Diane, graduate of the University of Delaware in communications, is working in the marketing department of Armstrong Cork at their regional office in Fayetteville, N.C. Young Dan continues in computer science at M.I.T.

One more aeronautical note before we go to sea: my own experience with airplanes (sorry, aircraft) this summer has been extensive and delightfully uneventful. Braniff, Lineas Aero Paraguay (L.A.P.), Varig, Vaspe, and Eastern Airlines carted me to and around Brazil and home again. The high point historically speaking was the leg from Rio to Ascuncion, Paraguay, in an Electra. Old planes never die; they go to Paraguay. Their

737 that took us over the Andes from Ascuncion to Lima and Miami (after an unexpected layover in Paraguay during Hurricane David) had PanAm logos on the safety-belt buckles. ('Nuff said.)

To sea: **Joseph Deal** has moved from Washington, D.C., to Fort Lauderdale to become president of Tracor Marine, Inc., a firm engaged in ship repair and ocean technology services. . . . **Bob Creek** is catching us up gradually. He has been an A.A.A.S. Fellow since 1972. We'll learn more when I catch up to him. . . . From Columbus, Ohio, (all I get on those $$$ envelopes is the postmark, boys) comes a note from John Shrack: "Started JaRack Industries for the purpose of sales and installation of air conditioning and contamination control systems."

C. F. Jenkins reports: "I've spent the last year on a Department of Commerce fellowship working with the House Committee on Science and Technology. It's been a fantastic experience, and I'm now returning to my lab in Ann Arbor, Mich." . . . **Claude Brenner** is one of the featured lecturers in this winter's Boston Seminar series, and his subject will be "Energy, Abundant and Cheap: What Are the Prospects?"

John Karmazin will be monitoring the solar energy system on top of the new Karmazin research and development building in (brrr) Michigan. It uses a special solar collector constructed with a patented nested fin design. They will be studying it while heating with it. The latest Karmazin News, beautiful in color (including a nice picture of John, chairman and president), also tells of plans for a large research wind tunnel for heat transfer testing of air-to-oil coolers and air-to-water and air-to-air heat exchangers.

Dick Knight and **Ginny Grammer** (*c'est moi*) are on the Technology Day committee for 1980 (and, I am afraid, beyond. . .)

The M.I.T. Alumni Summer Institute at Aspen gets good press from **John Kellett**. He writes: "I enjoyed the week tremendously and found the presentations and discussions most stimulating and thought-provoking, especially those by Dr. Neff and Professor Thurow which covered fields in which I am working (energy and economics). I also thought the facilities (both for meeting and for living) were good and the program and arrangements well planned. I particularly enjoyed the Aspen Festival concert, the Aspen Institute lecture by Alvin Weinberg and the steak fry trip. The 80 or 90 participants attending most sessions were a responsive group with much worthwhile dialogue with the lecturers, but I feel that is about the maximum number without losing effectiveness." We'll keep Aspen in mind for next year, John.

I am sorry to have to report the death of **Victor Azgapetian** of Costa Mesta, Calif., in November, 1978.

Thank you for your many contributions. Keep 'em flying this way. — Love, **Ginny Grammer**, Secretary, 62 Sullivan St., Charlestown, MA 02129

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The New York Hospital-Cornell Medical Center sent information about **Ken Brock**'s new job as their director of capital and special projects. Ken will have responsibility for their Third Century Program with an objective of $270 million. This program will strengthen the Center through the endowment of chairs, support of junior faculty and scholarships and increased funds for research and education programs. This effort should bring Ken's lifetime collections to a billion dollars!

Harry Meyer was elected vice president of Crouse-Hinds Co. Harry is general manager of the company's Arrow-Hart Division in Hartford.

Harry Ottobrini resigned as president of his company after its acquisition by a large German corporation. At the time Metceram was the largest U.S. company specializing in ceramic integrated circuit packages. Harry is seeking to buy a manufacturing company with a proprietary product. He would appreciate suggestions from classmates.

John Nicholson has completed 25 years with Shell Oil. He is complex superintendent at Shell's Wilmington, Calif., complex. His oldest daughters are employed at Superior Oil and Texaco in Houston after graduating from University of Illinois and University of Texas. His son is in college and his youngest daughter is in high school. . . . **Mel Posin** is co-founder of Printronix, Inc., manufacturer of medium speed line printers for computers. . . . **Ed Mack** is still at J. G. Milligan Co. in Oak Creek, Wis. He and his wife, Elizabeth, live in Hales Corner just south of Milwaukee with their son, who is finishing sixth grade.

Brom Muller is manager of New Product Development for B-D Medical Products. He moved to Rutherford, N.J., from Fairfield. Two of his children have graduated from college and two are still in college.

Allen Amdur is process engineering department manager for E. R. Squibb and Sons. His wife Marilyn is employed by Hanover Township Board of Education as coordinator of language arts and social studies. Their daughter, Nikki, is a copy editor for *Time* and *Life* magazines. Their son, Henry, is married and a third-year medical student in Mexico. Allen is a grandfather.

John Kaymen retired a year ago from U.S. Steel and is now working as a manufacturer's agent. John and Eunice just returned from a two-week visit to France where Stanley, their youngest, is a student at "Science Po" in Paris. Their daughter, Amelia, is working with patients in her RUSH medical school program.

Dave Freedman has retired for the second time in four years. Life is beautiful. He spends five months in Florida and seven months in Newton, Mass. Tennis, bridge, golf, sculpture and M.I.T. telethons keep him busy. Dave sold his bakery business in 1975. He started again, but gave the second business to his two sons.

Bud Garforth had a visit from Ginny and **Bill Osgood**. . . . **Pete Richardson**, director of admissions at M.I.T., spoke about college admissions to the 1979 convention of the Eastern Massachusetts Association of National Honor Societies.

Robert Heikes, former assistant general manager for the semiconductor group of Motorola, Inc., joined National Semiconductor Corp. in the new post of vice president, international. Bob will be responsible for all European and Latin American business.

Dick Harris and entertainer, Bob Hope, received honorary degrees from Central New England College. Dick is a member of the board of trustees of the college and served as chairman of the board from 1974 to 1977. Dick is president and treasurer of Curtis and Marble Corp. He is a director of Clinton Plastics, Associated Industries of Massachusetts, and AMATEX Export Trade Association. He is trustee and board investment member of Peoples Savings Bank; vice chairman of the board of overseers at Old Sturbridge Village; vice chairman, Special Committee for Workplace Product Liability Reform; and president of the American Textile Machinery Association.

John Avallon, president of the G.T.E. Lighting Group, a division of General Telephone and Electronics Corp., was elected by the Shawmut Merchants Bank to their board of directors.

On behalf of our class, I extend our sympathy to Judith Gutman who is the widow of our classmate, **Alfred S. Gutman**. — **S. Martin Billett**, Secretary, 16 Greenwood Ave., Barrington, RI 02806

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Norton Belknap has been named Senior Vice-President of Exxon International.

Milton G. Hulme, Jr., President and Chief Executive Officer of Mine Safety Appliances Co., President of Catalyst Research Corp., and Chairman of Thorofare Markets, Inc., was recently elected a director of Reading and Bates Corp. in Tulsa, Okla.

Lee H. Powers just returned from 14 months in the Ural Mountains of the Soviet Union working in a Soviet automobile plant. Of the assets Lee acquired on this trip were a little language ability, an insight into the system, and a Russian wife — not necessarily in that order. **Daniel G. Fawcett** just returned from a wonderful vacation on Maui with his wife Nancy and his youngest son, Dean. Dan is presently Section Head in electronic warfare at Hughes Aircraft in California. Ben Park, '67, works with Dan.

Eli I. Goodman has authored an interesting article on Three Mile Island. For those interested, we refer you to the June, 1979, issue of *Nuclear News*, a publication of the American Nuclear Society.

Sam Raymond just returned from a three-week stay at the North Pole with the National Geographic Society and the Canadian "Lorex" expedition. Sam took photos of the ocean floor using "Edgerton"-Benthos cameras.

Richard C. Brogle was recently appointed vice president at Block Drug Co. located in Jersey City, N.J.

Plans are underway for our 30th Reunion. Be sure to reserve **June 5, 6 and 7, 1980**, for this important affair. Keep tuned for further news. — **John T. McKenna, Jr.**, Secretary, One Emerson Place, Apt. 11H, Boston, MA 02114

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In the October issue of *Technology Review* we indicated that we would give you the results of the class questionnaire mailed out before our 25th Reunion. **Bob Evans** analyzed this questionnaire, and did a great job presenting it at the reunion. For the benefit of those who were unable to attend, Bob's review is enclosed.

A questionnaire was sent out to all classmates; approximately one-third replied. Whether the picture of our class would be very different if all had replied is unknown. Many of us are still in New England with about one-third of us living there — little changed from what we reported at our Fifth Reunion, but greatly exceeding the 3.8 per cent of all Americans who live in New England. While some of us remain firmly anchored in New England, the class as a whole is slipping south and west as the years go by. Almost 20 per cent of the class now lives in the Southwest and on the West Coast compared to the approximately 12 per cent who lived in those areas in 1958. Regardless of where we live, we are overwhelmingly home owners (93 per cent) and we live outside the city. Less than a quarter of us are in the city (22.6 per cent) and about two-thirds (63 per cent) report living in suburbia.

As a class we are married, and happily so. Almost 90 per cent are currently married and 85.5 per cent of those are married to their first wife or husband. At one time or another 96.3 per cent of us have been married. 13 per cent of us have been divorced at one time or another, a rate below the national rate of 17 per cent for individuals of our age. These marriages, first and subsequent, are described as "super" by 58.8 per cent of us, "good" by 33.0 per cent and "not so good" by only 8.2 per cent.

The average number of children (for those having them) is 3.0, with about one-quarter of the class having more than 3. Very few of us (4.4 per cent) reported having a student at M.I.T., though 71.6 per cent of us would encourage a child to attend M.I.T., down about 15 per cent from our views in 1958. We ourselves, however, would attend again — some 89.7 per cent of us, with 70.1 per cent of us taking the same course.

Despite the technical nature of our education, our principal occupational category is management, 41.2 per cent, with research and development at 19.2 per cent the second most popular field. About one-third of us (29.4 per cent) report owning our own company. And we enjoy our work. 41.3 per cent report that they look forward to going to work, and an equal number are content. Some 7.5 per cent are looking for another job, something most of us have done more than once. About one in seven of us have had only one employer while almost the same number report more than 5 employers. The median number of employers is 3.

On the whole we are well paid. The estimated average salary was $46,650 and the median was

$41,616. Our median is more than three times the $12,800 reported for the class of 1963. Unfortunately, much of the increase reflects inflation. In constant 1958 prices our median salary has risen from $7,000 in 1958 to $18,446 in 1978. Alternatively, 1958's median of $7,000 would have been $15,794 in 1978 prices.

When we were at M.I.T. almost half of us (43.2 per cent) considered ourselves to be neither conservative nor liberal, and another third were conservative. Since then about one-third (37.8 per cent) have become more liberal and two-thirds (62.2 per cent) have become more conservative.

Our habits are not too bad. Less than a quarter (21.9 per cent) smoke, a figure that has been cut in half since 1973 when 42.6 per cent said they smoked. Again, about one-quarter of us drink rarely (21.5 per cent), and about the same number drink a great deal (22.0 per cent). We divide on exercise with 56.3 per cent saying that they exercise regularly. About half of us watch less than 5 hours a week of TV and only 2 per cent of us watch more than 20 hours. This was similar in 1963, though we watch perhaps a little less. What has increased are the hours spent on hobbies. One-quarter of us (24.2 per cent) spend more than 11 hours a week on hobbies compared to only 10.5 per cent in 1963. We listed some 45 separate hobbies. Reading (15.7 per cent) and travel (8.3 per cent) lead the list. They were followed by skiing, tennis, and gardening. Culturally most of us had been to plays, concerts and museums during the past year, but only a few of us go to the opera.

Travel is our favorite vacation activity. Some 29.1 per cent have travelled abroad, and 22.8 per cent have travelled in this country this past year. About half those numbers went skiing and to the beach. About one-quarter of the class owns a boat (28.0 per cent) and a vacation home (23.4 per cent), but only 2.3 per cent report owning an airplane.

We have good marriages, but what of other goals? One-fifth feel that they are living much better than they expected, one-third that they are living somewhat better and another third are what they expected to be. Statistically, the years seem to have been good to us, a conclusion reinforced by impressions from the reunion.

The House of Vision, Inc., recently announced that **John E. Preschlack** was elected to its Board of Directors. Jack is presently chief executive officer and president of General Binding, Inc., in Northbrook, Illinois. Jack was formerly president of the graphic products division of Itek Corporation in Lexington, Mass. Prior to joining Itek he was a principal of McKinsey and Co., international management consultants. Jack is a graduate of Course VI who went on to get an M.B.A. from Harvard Business School where he was a Baker Scholar. In December 1978 he received an M.I.T. Corporate Leadership Award presented to alumni whose responsibilities in private industry mark them as exceptional contributors to the strength and well-being of the United States. Jack, his wife Lynn, and his three sons live in Lake Forest, Ill. . . . We also have a report that **Fred West** came in from New York to attend the American Astronomical Society in Wellesley, Mass., on June 11 through 14.

We will continue to send you various notes on our 25th Reunion as well as any information you may care to send along to us. — **William Combs**, 120 West Newton St., Boston, MA 02118; **John Kiley**, 7 Kensington Rd., Woburn, MA 01801; **Louis E. Mahoney**, 14 Danby Rd., Stoneham, MA 02180; **Dominick Sama**, Chestnut Hill Rd., Groton, MA 01450

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Remember our Twenty-fifth! I don't want to use scare tactics, but we are getting non-young. Our reunion next year is going to mark a passage, and you can be a part of that: looking forward as well as recalling friends and familiar scenes. And there is an opportunity to contribute to the outline of the picture that will be M.I.T.'s future. The renovation of 10-250 is the twenty-fifth reunion project of the class of 1955. Our gifts are acts of faith in the future students of M.I.T. C. S. Lewis said, "The present is the point at which time touches eternity." Look to our twenty-fifth reunion as a point from which both the past and the future are on view.

John M. Dixon is in his eighth year as editor of *Progressive Architecture*, which won a coveted National Magazine Award this year. Also, he had an article in a recent *Technology Review* (May 1979). He and Carol are still living in Old Greenwich, Conn., where she is "Chairman of the Arts" at Greenwich Academy. Their son Peter has completed his first year at Harvard, and daughter Susannah is the star of the high school track team.

In 1978 **Eldon H. Reiley** was a visiting professor at the University of Warwick, England. He and his daughter enjoyed living for nine months in the shadow of Warwick Castle. Eldon concludes that England's greatest cultural contribution is real ale. **Sheldon Busansky** is moving to Tampa, Florida to become vice president and general manager for Honeywell's Tampa operations. **Daniel Myers** is alive and well, living in Palo Alto. He has been working for Envirotech as manager of contract administration since graduating from law school in 1970. He says that he has been making good wine for the last ten years, and he is looking for the opportunity to go commercial. Panic at Paul Masson. **Eric Theis** reports that his oldest son Eric, Jr. is at Miami University, while son John is an exchange student in Sweden, and son Frank is sailing a square rigger off the coast of Florida for the summer.

Dave Brooks recently sent us a letter bringing us up to date on events in his life. He moved to Canada in 1973, when he created an Office of Energy Conservation for the Canadian government, and served as director until 1977. In 1977, he left government and organized Friends of the Earth in Canada. He now serves as president of this organization, and works for Energy Probe, one of Canada's main environmental/energy groups. A few months back the Economic Council of Canada published a monograph of his on the economics of low energy growth. Dave writes that his interests lie in the area of energy demand and conservation, and that he is a devotee of soft energy paths (alternative energy systems). — Co-secretaries: **Marc S. Gross**, 341 South Bedford Dr., Beverly Hills, CA 90212; **Allan C. Schell**, 19 Wedgemere Ave., Winchester, MA 01890

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Over the summer, the postman rang twice — or more — and so we have good news of classmates far and near to brighten your Thanksgiving holiday. First, a few short takes.

From afar, **Mike Balderston** says that he is sorry to have missed the 20th Reunion; "it was just too far from Australia and Hawaii." But he hopes to make the 25th. If you've seen the airports this summer, it's not too soon to make your reservations. . . . From beautiful downtown, nearby Newton, Mass., **Cole Bess** wants to know: "Who else in our class completed the Boston Marathon in 1979?" Just to be sporting, your secretary offers one free lunch to all '58 classmates who qualified and finished. To win, send a documentary letter along with the left shoelace from the running shoes you wore; then appear personally at my office in Boston to collect your prize. (Offer still valid for the 1980 Boston Marathon.)

While attending an American Railway Engineering Association regional meeting in Minneapolis, **Mike Kenyon** saw **Dave Larson**, who is teaching school in the Edina, Minn., system. . . . **Edwin Pearson** recently assumed the position of director of the Legal Aid Society in Omaha. . . . This year, **Ahren Sadoff** is taking his sabbatical at Berkeley to investigate the effects of radiation on cancer cells. He is a professor of physics at Ithaca College and involved in the new Cornell storage ring.

After the full-time academic life at the University of Miami Medical School, **Lee Bricker** writes that he is "enjoying private practice in endourinology and clinical nutrition in Miami. Myrna is now in law school and our sons David (14) and Steve(10) are doing fine." . . . **Mike Greenberg** is presently director of hardware engineering at Functional Automation, Inc., in Hudson, N.H. . . . **John Thorpe** reports the publication of his new book, *Elementary Topics in Differential Geometry*, a junior/senior-level text.

Sig Silber sent along a clipping about "hizzoner" **Bill Dreier**, who received an outstanding achievement award from the National Institute for Child Custody and Divorce Awareness. (As a divorced father with custody of his son, I can offer a special note of congratulation and express the wish that this organization had been more broadly active earlier on.) Sig is still actively engaged in private practice in his hometown of Paterson, N.J., and has a mix of small business, corporate, and patent, trademark and copyright practice.

Dick Rosenthal, of 20th Reunion photo-button fame, recently completed his tenth year with Polaroid. Dick was also promoted to technical manager in the instrumentation engineering division. . . . Another reunion committee member, **Mark D'Andrea**, has been promoted to manager of special processes at the G.E. Aircraft Engine Group in Lynn. He is responsible for all manufacturing process support other than conventional machining operations. (See what reunions do for you?)

Not only has **Bob Parente** just recently started his own management consulting firm, but he and Rozalinda have started their family with their first child, Jennifer Dee. (The management of the reunion, by the way, assumes no responsibility for this happy event.) Bob's firm is in the Los Angeles area. . . . At Opinion Research Corp., an Arthur D. Little subsidiary, **August Hess** was promoted to senior vice president. As director of marketing models, he is responsible for the design and development of computer systems supporting O.R.C.'s marketing profile service. . . . That is all until next month — the last of the seventies. And for all of you who snow me under with Christmas and holiday cards each year, please note my address change here — **Michael E. Brose**, Secretary, 59 Rutland Square, Boston, MA 02118

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This, my first column as Class Secretary, will be rather brief for two reasons. First, I just woke up to the fact that the deadline for this issue is less than 48 hours away. Second, there seems to be little new news to report — **Allan Bufferd** having exhausted the mail bag with his last column.

Let me start by offering an apology to **Bob Rosenfeld** who was the real winner at the Class of '59 golf outing. Of course, there are many who accuse him of playing under an assumed name to gain a few extra strokes. It was great fun seeing Bob and Linda after so many years and catching up on all that has transpired. **George Barnett** was at the reunion with his family and has since written to say that he will be in his own private law practice as of the end of the summer. All clients are gratefully accepted. George is also Membership Chairman for the M.I.T. Alumni Center of New York and reminds us all to join.

Bob Baker has been appointed Vice-President — Freight Marketing for American Airlines. . . . And the (University of) *Wisconsin State Journal* reports that **Charles Hill** has been selected to receive a Distinguished Teaching Award. He has won departmental Outstanding Instructor awards in four of the last ten years. Charles also advises a student chemical engineering group and is the author of a widely-used textbook on chemical engineering kinetics and reactor design. . . . **Elmer F. Delvental** writes to say that he is sorry he missed the reunion, but a load of work, the teaching of a summer course, and taking two courses required for his doctorate was just too much to leave for several days in Cambridge. . . . **Charles C. Francisco** has been elected a Vice-President of EG&G, with responsibilities for the Environmental Group.

Dick Sampson read a note from **Bruce Blom-**

strom at the class banquet. In part, Bruce wrote that he would be unable to be with the Class on the Twentieth Reunion since he had assumed the position of Executive Managing Director of Abbott Laboratories' joint venture in Osaka, Japan, only several months before. He goes on to say that he spent the previous two years as General Manager of Abbott's company in South Africa. Bruce and Anne have two children — Jeffrey, 13, and Kristin, 11 — who have also settled well into their new life in the Far East. Having spent three years in Tokyo with IBM-Japan, under the same general circumstances — my wife, June, and two children Nancy and Gary who were then (1974) also 13 and 11 — I can understand, appreciate, and envy Bruce's position.

Lastly, I am sorry that I must write that **John R. Mann**, 5 Perham St., Bedford, MA 01730, passed away on June 5.

Please drop me a line, else I'll be forced to invent a new classmate or two to keep the column filled. — **Larry Laben**, Secretary, 310 Rockrimmon Rd., Stamford, CT 06903

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On a recent trip to the Naval Air Development Center I visited **Jim Duke**, who is project manager for improved magnetic anomaly detection systems. Jim has been at N.A.D.C. since graduation, with time off for a Ph.D. in automatic controls from R.P.I. He lives in nearby Buckingham with his wife, Irene, and their children, Jamie (6) and Pamela (4).

Jim Pennypacker

Jim Pennypacker has made the transition from inertial guidance to financial guidance, beginning in Course VI at M.I.T. and recently being named vice president in the trust and investment division of Chemical Bank in New York. He is responsible for custody services accounts and has had prior experience with the bank's trust automation department and personnel group. Earlier, he was on the M.I.T. staff, where he published articles in inertial navigation, computer simulation, and financial modeling. He lives with his wife, Elise, and children, Stephen and Bruce, in Stamford, Conn.

Tom Farquhar

Also in the financial arena, class treasurer **Tom Farquhar** has become a senior vice president of Massachusetts Financial Services Co. Tom joined M.F.S. in 1969; he is a member and past chairman of the Investment Technology Symposium of the N.Y. Society of Securities Analysts and a member of the Operations Research Society and the Institute of Management Science. . . . **Vernon Yoshioka** has been elected to a one-year term as president of the San Diego City College Citizens Council. . . . **Bill McBride** is with Digital Equipment Corp. in Marlboro; he lives in Sudbury with his wife Barbara, and their sons, Alan (13) and Jonathan (7). . . . **Richard Blahut** is a senior engineer with I.B.M. Owego, where he has had general responsibility for the analysis and design of coherent signal processing, digital communication, and statistical information-processing systems. He received his Ph.D. in electrical engineering from Cornell in 1972 and has been an adjunct associate professor there since 1973. . . . **Girts Ozolins** reports that he is currently running marathons in the Southern California area; he has qualified for the biggy in Boston but has not made it back for one — yet.

Now you can call me Ray, or you can call me Jay, or you can call me R. J., but don't call me for a reminder that our 20th reunion is getting closer. Tech Night at the Pops will be held on June 5, and Technology Day follows on June 6, so plan ahead. — **Robert F. Stengel**, Secretary, 329 Prospect Ave., Princeton, NJ 08540

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Though you are reading this in November, I am writing it in early September, at the conclusion of a marvelous summer for the Bertin family. Barbara and I made two backpacking trips to the Sierras; we enjoyed the scenery, the fishing, and plenty of relaxing. For those of us who live in a high-technology world, there is something about the mountains that helps put things in their proper perspective. Our summer also included a visit to our daughters at camp in Connecticut. We swung up through New Hampshire and down to Boston before heading back to the West Coast. Living in California, one can forget the rural charm of New England. Even with all the building going on in this state, you are closer to the woods in Boston than in Los Angeles. (That wasn't always true.)

We stayed one evening in July with Carolyn and **Ira Blumenthal**. The Blumenthals were also enjoying a childless month, having sent Billy and Robin off to camp. Carolyn put together a dinner party, and we spent the evening with old friends — classmates, of course. Margie and **Larry Krakauer** were there, and Larry was in rare form. He had plenty of stories about man-machine interactions at M.I.T.'s Artificial Intelligence Lab. He told about **Frank Model** playing one of the early chess programs. A large part of Frank's game involved psyching his opponents — the machine, of course, was unflappable. The computer won the first match, but, after re-evaluating his tactics, Frank took the second game. **Marty Schrage** told about his weekend condominium in Conway, N.H. (Skiing anyone?) Martin had just returned from a business trip to France, and one of his souvenirs was a confectionier's jacket. (Candymaker, for those of you who don't speak French.) Carole and **Pete Van Aken** were at the party, too. In May, Pete was promoted to vice president of budget and analytical services at Brandeis University. He will be responsible for the collection, processing and analysis of data required for decision making and financial planning.

The following evening we had dinner with **Frank Model** — but he didn't have any stories to tell about Larry. The Models have moved to Long Island after two years in Ann Arbor, Mich. Frank is with Pall Corp., and is still doing membrane research.

When we arrived home we had the pleasure of a two-day visit from Julia and **Larry Beckreck** and their sons, Seth and Joshua. The Beckrecks are living in Longwhaton, in the U.K., and were visiting California for the first time in seven years. The boys were having quite a time — filling up on Disneyland, baseball, and Big Macs.

Bonnie and **Herbert McClees** sent me a card announcing the birth of their first child, Johanna Ellen, last April 8. Congratulations and welcome to parenthood!

Bill Baugh wrote that during June and July of 1978 he attended the National Security Education Seminar held at Colorado College under sponsorship of New York University's National Security Program. Then last fall he moved west, and became an assistant professor of political science at the University of Oregon.

Jonathan Gross reports that his second book *FORTRAN 77 Programming*, coauthored with W. S. Brainerd and C.H. Goldberg, and his third, *Introduction to Computer Programming*, with the same coauthors, were recently published by Harper and Row. **Michael Feld** was named to the rank of full professor in the Department of Physics at the Institute. He is a leading investigator in modern optics. One of his current areas of interest is using laser optical pumping to align short-lived atomic nuclei to determine their electromagnetic properties. **John Addis** informs us that he and Wink Gross, EE '73, designed the vertical amplifier the Tektronix 7104 oscilloscope — at 1 GHz bandwidth, the world's fastest conventional scope. John is still a bachelor and is living in Portland, Ore. After viewing the February 26 solar eclipse, John visited Richie Garber, '62, whom he had not seen in 17 years. While John was there, Richie received a letter from **Ric Hoffman**. All three were residents of East Campus' infamous Fifth Floor.

We note with sadness the passing of **Richard Olson** last February, in Los Alamos, N.M. Dick was a physicist working at the lab there. . . . At the awards convocation last May at the Institute the **Harold J. Pettigrove** Award was presented to Peter W. Lemme, '80, the Intramural Chairman. The award is in memory of the late Hal Pettigrove, and is in recognition of outstanding service to intramural athletics. Hal was active in intramurals as a player, as a referee in football, basketball, and other sports, and in helping to administer the intramural program.

I am still working on a small surplus of envelope flaps and press releases, a very unusual situation. Don't let that discourage you, however. Drop me a Christmas card, let me know how you're doing, and sooner or later your news will appear in this spot. Happy Thanksgiving. — **Mike Bertin**, Secretary, 18022 Gillman St., Irvine, CA 92715

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We have enjoyed a delightfully hectic summer. Kicking it off with our "now-history" 15th, we followed it up with a July/August combined business/pleasure trip to California. We had fun covering California from San Diego to San Francisco, including stops at Huntington Beach, Disneyland, and Thousand Oaks. Some of the sights we can recommend are the San Diego Zoo, Wild Animal Park, Sea World, Knott's Berry Farm, Universal Studios Tour, Sausalito, Muir Woods, and many cable car rides and numerous drives down Lombard Street (the "crookedest" part). Naturally, it helps to have your children along (as we did) to enjoy some of these places, but it is hardly a prerequisite.

While in San Francisco, we spoke to **Mark Radwin** several times, but we were unable to hook up our schedules. Wrapping up our summer, we came home to good news, learning that I was elected a vice president of ManTech. On to our class news.

We have a nice letter from (Leslie) **Bud Boring**, the resident vice president of Citibank in Cairo, Egypt. Bud had hoped to join us at reunion time, but pressing business activities ultimately prevented him from getting away in time. Bud has just successfully completed managing the opening and first year and a half's operations of Citibank's Alexandria (Egypt) branch. For his next assignment, he'll head up Citibank's Corporate Bank in Amman. Nicolas, their son, is three now (when you read this) and speaks French to Annie and English to Bud, with a word or two of Arabic tossed in here and there. Hope you had a nice "vacation" in Paris, Bud, and good luck in Amman.

Ron Gilman reports that he and Betsy are enjoying life and watching their two daughters, ages 11 and 8, grow up. Ron was just appointed

one of nine members of the Tennessee Court of the Judiciary, a newly created body to hear complaints concerning the performance and fitness of state judges. The most important thing that has happened lately, however, according to Ron, is his joining the International Brotherhood of Magicians and the local "ring" in Memphis! So far Ron's appearances have been limited to his daughters' birthday parties and Betsy's preschool class. He says that's about all that coincides with the present extent of his magical ability. (The Schlossers also send best wishes to all the Gilmans.)

Now to our alumni fund envelopes. **John Enyedy** is the international marketing manager for National Information Systems, a computer software company headquartered in California. He's married and has 3 children. . . . **Larry Hendrickson** has been appointed Director of Strategic Planning at A.T.&T. in New York City. His wife, Dale, is Director of Medical Records at Memorial General Hospital in Union, N.J. . . . Another classmate living in California is **Robert A. Hill**. Bob is currently manager of the Laser Technology Department for Hughes Aircraft Co. in Culver City, Calif., and he has recently remarried. Bob, his wife Linda, and her daughter Lynette are all avid skiers.

Dick Hodges is still single and works as lead scientist for (can't read the company's name, help!) Inc., a small defense contractor. His work is mostly military operations research. Dick says it's really playing war games involving submarines on a computer. . . . **Bob Popadic** recently joined the Financial Industries Section of Arthur D. Little, Inc.

Mark Ain has started his own company, Kronos Inc., after seven years of successful management consulting. His partners are also from M.I.T. but represent different classes — Sheldon Apsell, '65 and Larry Baxter, '59. With the help of a fellow '64 classmate **Donald Levy**, they have developed a modern timeclock/computer peripheral employing standard timecards. Mark is living in Newton, Mass, close to Brighton where Kronos, Inc., is located. By coincidence we received an alumni fund envelope with news from **Donald Levy**. Managistics, Inc., the computer service business Don founded and managed since 1968, was sold to the Chase Manhattan Bank in November, 1978. He is staying on with Chase as president of the new subsidiary.

While at the reunion we were lucky enough to corral some of our classmates and over the next few issues we are assured of having some news to print, but we still want to hear from the rest of you classmates.

Our class president was one of those who jotted down some notes for this column. Sue and **Dave Saul** are living in Wayland, Mass., with their sons — Michael, 7, and Jonathan, 4. Dave is a project manager with I.B.M. at the Cambridge, Mass., Scientific Center. He is responsible for advanced technology projects in computer science. Some of Dave's hobbies are gardening, photography and collecting Sherlock Holmes books. Thanks for the news, Mr. President!

The person responsible for the class treasury is **Bruce Strauss**, another willing(?) classmate who gave us the following news. Bruce has recently returned to Boston after 10 years as a high-energy physicist in the Chicago area. He worked at the Fermi National Accelerator Laboratory where Bruce was assistant director of the energy doubler magnet group. Now he is at M.C.A. as engineering manager for new ventures. Bruce put a P.S. on his note about a fellow classmate: **Bruce Chrisman** was just named business manager of Fermi National Accelerator Laboratory.

We'll save the rest for the next few issues. Happy Thanksgiving! Ciao! — **Steve Schlosser**, 11129 Deborah Dr., Potomac, MD 20854

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This month's class hero is **Bill Pike**, who wrote to tell us about his engagement to Karen Fischer, an abstract artist specializing in print-making. Bill, has been in the investment business for eleven years, the last seven at Fidelity Management, where he is an equity analyst and portfolio manager. Bill and Karen have bought a condominium in Cambridge.

The rest of this month's news is from the back of Alumni Fund envelopes: **Robert Goldberg** went from M.I.T. to Harvard, where he obtained a Ph.D. in computer science and then did research at Lincoln Lab. From Honeywell, Bob went to cofound BGS Systems, Inc., a consulting and research firm with special expertise in software and computer systems capacity planning. Bob and Judith have four children: Alexander, 6, Alison, 5, Jeremy, 3 and Daniel, 3; they make their home in Newton Highlands, Mass. . . . **Dan Diamond** ran into **Ed Yourdon** at the National Computer Conference; to quote Dan, "Even though he is rich and famous now (Yourdon, Inc.), he's still a great guy." . . . **Chuck Seniawski** has returned from Johnson Atoll to Malstrom Air Force Base at Great Falls, Mont. . . . **Ralph Cicerone** is still doing research in atmospheric chemistry at the Scripps Institute in San Diego. He received the MacElwane Award of the American Geophysical Union for "significant contributions to geophysics by an outstanding young scientist." . . . **Pierre Perrolle** is still working for the National Academy of Sciences' Committee on Scholarly Communications with the People's Republic of China, and spent three weeks in May and June visiting nuclear research laboratories in China. Pierre is editor of a new quarterly journal, *Chinese Science and Technology*. . . . **Michael Adler** has been appointed manager of the Device Physics Unit at the General Electric Research and Development Center at Schenectady, N.Y.

Finally, remember that our 15th is approaching! Save the dates of June 5 through 7. Any volunteers to help with the planning? — **Edward P. Hoffer**, M.D., 12 Upland Rd., Wellesley, MA 02181

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It is with particular pleasure that I pass on to you notice of three more '66 class members who have completed doctoral studies. **Aaron Klappholz** earned his Ph.D. in 1974 from the University of Pennsylvania, **Karen Shields Atwood** received her J.D. this past June from the New England School of Law, and **Michael Shorenstein** recently supplemented his Ph.D. with an M.D. from Stanford University Medical School.

Aaron was an assistant professor of computer science at Columbia University from 1974 to 1978 when he joined the Polytechnic Institute of New York as an assistant professor. He is involved in the design of a highly parallel supercomputer. Two years ago Aaron married Inna Brorman from the U.S.S.R.

Karen and her husband have three children: Ellie Baptiste, Tom and Kira. She distinguished her law studies by earning the American Jurisprudence Book Award for the highest grade in the land use course.

Michael and Roz, his wife, have kept their vocations all in the family. Both received engineering Ph.D.'s in 1972, and both subsequently changed fields to enter Stanford Medical School. Michael and Roz exhibited great patience in selecting Stanford over the University of Miami's two-year M.D. program for Ph.D.s. They shared the finish of their medical school days with a daughter, Anna Irene, now 4 1/2. They were interns and senior residents at U.C.L.A. Hospital and are now initiating a joint practice in internal medicine in Santa Cruz, Calif. Now, Michael and Roz hope that their new home near Redwood Forest, golf course, and Pacific Ocean survive nuclear power plants and earthquakes to provide them a permanent home.

Congratulations to **George Eldis** who has been named manager of ferrous metallurgy at the Climax Molybdenum Co. research laboratory in Ann Arbor, Mich. Congratulations also to **David Liroff** who will begin as broadcast manager for the Greater Boston Educational Foundation — WGBH-TV, Channels 2 and 44.

Paul Lafata lives near me in Rockville, Md., and is manager of the Teledyne Brown Engineering Co., Washington, D.C., office. Paul is married and has two children. . . . **Charles Erdelyi** recently moved from the southlands (N. Carolina) to Vermont. He works for the I.B.M. General Technology Division as an advisory engineer on logic circuit development.

Melvin Garelick, wife Jacqueline, and daughters Rachel and Joanna live in Setauket, N.Y. Melvin is a senior aerodynamicist with Grumman Aerospace Corp. working on advanced aircraft development. He flies his own airplane and has been into that for ten years. . . . **Richard Brady** gets the class entrepreneur of the month award for leading his Washington, D.C., area tenants association through a year-and-half struggle to purchase their garden apartment building for one million dollars. They were taking advantage of a D.C.-area technicality that encourages private citizens to negotiate their own purchase and save substantial sums of money. . . . **George Bourrie, Jr.** is working for Educational Computer Corp. in Stafford, Penn., and is taking courses at Villanova toward an M.S. in computer science. . . . **Donald Haney** is yet with the Air Force and is currently assigned to the Air Force Management Engineering Agency in manpower planning and research at Randolph A.F.B. (That's out in west Texas where seismic crews hustle jug lines in 105-degree sunshine.)

Mark Yogman serves Mobay's Polyurethane Division as product manager of elastomers. Mark markets weight-reducing urethane bumpers, fenders, etc., for cars that help improve gas mileage, and he secretly wishes that A. Sloan would have read this and put them on all G.M. cars. . . . **Michael Adler** and his wife added a second son to their family in 1978 and are planning to write a book on baby taming. He spent much of the past year rebuilding an old warehouse to create a modern office building and looks forward to an extended interval of not having to look at carpenters, electricians, plumbers, roofers, and so on.

Best wishes until the next issue. — **Joe Patterson**, Secretary, 1403 Gerard St., Rockville, MD 20850

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Jon Sussman was recently promoted to the position of business manager of the Test Equipment Manufacturing Group at Digital Equipment Corp. He and wife Margie have a new son, Daniel Jeffrey. . . . **Charles Gliniewicz** spent the summer building an addition to his house after a hectic school year at a new North Quincy high school. . . . **Stanley Rose** writes that he finds it hard to believe that so much time has passed since graduation. His daughter, Stephanie, has just "graduated" from kindergarten. . . . In August, 1978, **Paul Kyzivat** left Ford after 11 years and is now working on the architecture of new computers/operating systems at Honeywell in Phoenix. . . . **Barry Watkins** is an attorney with the city of Rochester, N.Y. . . . **Henry Link** spent six months on a Task Force of the M.D.C. in Hartford, Conn., studying solar and wind energy, composting toilets, and hydroelectric power potential in the M.D.C.'s water supply dams. He has served as a consultant to the energy conservation committee of the New England Energy Congress in Medford, Mass., and would like to hear from other grads working in energy conservation. He is now working in the water supply section of the Connecticut Health Dept. In his spare time he enjoys tennis, sailing and cross-country skiing and participates in some regional advisory committees concerning transportation planning and solid waste management. — **Jim Swanson**, Secretary, 878 Hoffman Terrace, Los Altos, CA 94022

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As the leaves start thinking about turning colors and the Congress returns to session, we send you greetings from the banks of the Potomac. The big news in town is that I recently switched jobs and moved from the Institute for Defense Analyses to

the Federal Communications Commission to work as Special Assistant for Technology Assessment to the chief scientist, Steve Lukasik, Ph.D. '53. As yet, the job duties are not completely defined, but my desk is getting buried very quickly. . . . We have one birth to report this month. **Doug Wilson** announces the arrival of his first son, Brant, in April, who joins Susanna, now 3. Doug has left EG&G after 3 years and has taken a job with Los Alamos where he's in the laser fusion theory group, designing the microballoon targets for high power CO_2 lasers.

I last saw **Owen Franken**, globe-trotting photographer, at our reunion one and one-half years ago and he said he'd been trying to write a letter to us for a few years. He claims to have finished one while in the Mauritanian Sahel last year, but then misplaced it. He recently wrote from Andorra while having lunch and waiting for a woman friend. ("I suppose I'm unique at least in that I'm probably the only M.I.T. alumnus with a girl friend in Andorra. The only probelm is that it's a real pain in the ass to get here.") The letter is quite lengthy so I will include only some of the details, but the whole text is available from NTIS on microfiche. Owen's most enjoyable assignment was covering Nixon's resignation and flight from Washington. Two years ago he spent three weeks photographing Palestinian refugee camps in Jordan and the Israeli-occupied West Bank and Gaza for the U.N. Refugee Agency. The experience left him with a strong pro-Palestinian position. Owen's home base is an apartment in New York that is decorated with pictures and items from his travels. As he travels greatly, he has an international network of friends that he swaps apartments with. If you live in an interesting place, especially Japan, he'd like to hear from you. His address is 61 W. 8th St., N.Y.C.

Jim Bixby is enjoying living with his family in San Diego where he is working in research at Spin Physics, Inc. . . . Holly and **Jack Russell** are living in the Big Apple with their children, Chris, 9, and Andy, 7. Jack is product manager for PVC compounds at Pantasore, Inc. . . . **Robert Levasseur** is manager of management science at Digital Equipment Corp. in Maynard and lives in nearby Westford. . . . We find two classmates out in San Francisco. **Bob Haslam** is an attorney in the Litigation Dept. of Heller, Erhmann, White, and McAuliffe, and is living in Oakland Hills. **Erich Schuetz** moved to the area to work with a small high-technology firm manufacturing automated optical instruments.

Craig Pynn has been promoted to marketing manager of Plantronics/Zehntel, Inc., a manufacturer of in-circuit test systems for printed circuit board production testing. . . . **Eric Li** is involved in large area thin film cadmium sulphide on flexible conductive substrates. Possible applications are electrostatic lithographic printing plates. . . . From Leominster, Mass., we hear that **Harry Goldmark** is practicing orthopedic surgery and enjoys living there with his wife, Nancy, and their son, Jamey, who is now 1 year old.

Michael Yokell has resigned his position as senior economist at the Solar Energy Research Institute to found Resource Management Consultants, Inc., an economic and technical analysis firm in Boulder serving the energy, resource development, and environmental communities. Pergamon Press recently published his new book entitled *Yellowcake: The International Uranium Cartel*. . . . Another entrepreneur is **Thomas Penn**, who has started a management consulting firm in Philadelphia and is returning to school at the University of Pennsylvania to study law.

Patrick Phillipps recently moved to Chesire, Conn., to take a position as electrical engineering manager at a nearby medical electronics company. He looks forward to hearing from nearby classmates. . . . Finally, Carol ('70) and **Neil Goldstein** are living in New York where Carol is a CPA and manager at Arthur Young & Co. and Neil is National Representative in N.Y. for the Sierra Club. . . . That's all for this month. We hope you have a nice Thanksgiving. — **Gail** and **Mike Marcus**, 2207 Reddfield Dr., Falls Church, VA 22043

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Having just returned from the World Science Fiction Convention in England, I am in good shape for this second installment of our class notes. After being involved in many different ventures the first eight years after graduation, I started Archival Press, a company publishing books, prints, portfolios, notecards, etc. Fantasy and science fiction are my main areas of interest.

Tim Merrill is working at the Lawrence Livermore Laboratory in Berkeley at their bio-medical division. Involved in flow systems engineering, his projects include cancer diagnosis, therapy, and cell kinetics. Tim is engaged to Joan McGuire, an elementary school teacher, and has as his main problem, "lack of time to do all I want to do!" Sounds familiar.

Still in Cambridge is **Mike Neschleba**, who is now a production manager in Polaroid's Film Division. . . . Evie and **Rick Dorman** just had their second child, and are living the suburban life in their house in Mayfield Hts., which is near Cleveland. . . . **Donald Vawter** and wife Elizabeth just had their first child a few months ago. Don is currently an assistant professor at Virginia Polytechnic Institute in Blacksburg, Va., with chief research interests in bio-mechanics.

Randall J. Hekman regrets having missed our reunion, but a heavy court schedule allowed no free time. Randall is still a probate judge working in the juvenile court division handling cases of child delinquency, neglect and abuse. He and wife Marcia did find time to have their fifth child, their first boy. . . . **Joel Morgenstern** is now into his third year at Stony Brook Medical School. . . . Having just gotten his Ph.D. at M.I.T., **Bruce Heflinger** is now eager to start working in the real world. . . . **Joseph A. Horton** is now chief of neuroradiology at West Virginia University Medical Center. With rank of associate professor, Joe is rather satisfied with his situation.

Those of you who have sent in information for the class notes, now and in the past, have been struck by the delay in publication. The newest message forwarded to me by the Alumni Association is two months old, and what I write today will not be printed for another two months. All information I receive will be in the soonest possible edition of class notes. — **Robert K. Wiener**, Secretary, Box 27, M.I.T. Branch, Cambridge, MA 02139

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First, an important reminder and call for action — our Tenth Reunion should be held in June, 1980. For there to be success, we need immediately to organize, plan, and arrange whatever activities are desired. Present M.I.T. plans include Tech Night at the Pops on June 5 and Technology Day on June 6.

Joseph DiLiberto has recently taken a position as Manager of Advanced Engineering Technology in the Monroe Divison of Litton Industries in Morris Plans, N.J. . . . **Jim Kates** works at Signatron in Lexington and is a recent father — his second daughter. . . . "President, Editor, and Publisher of a great metropolitan daily" — sounds familiar and describes **O. Reid Ashe, Jr.** He married one of his reporters and is with the Jackson *Sun* and evidently enjoys the small college town life. His other major activities include Y.M.C.A. work. . . . **Steve Oreck** graduated from L.S.U. Medical School and is returning to Boston for his surgical residency at Tufts-New England Medical Center. . . . The position of Vice-President has been accepted by **Bill Wong** at National Bank of North America. He had been with the bank's international division. . . . **Ronald Stoltz** is involved in the nuclear applications field with Sandia Corp. in Livermore, Calif.

Thomas M. Devine, Ph.D., received the highest honor given by the American Society for Testing Materials, the 1979 Vilella Award, for his paper on corrosion. He accepted the award along with co-author Harvey Solomon at the Society's annual meeting. Tom has authored twenty papers in various metallurgical fields.

Harvey D. Solomon (left) and Thomas M. Devine, '70, metallurgists at the General Electric Research and Development Center, review their paper on corrosion, which recently won them the 1979 Vilella Award of the American Society for Testing Materials.

Tom has been with the G.E. Research and Development Center in Schenectady since 1974, and lives in Niskayuna with his wife Trisha and his two children. — **Robert Vegeler**, Secretary, 2120 Fort Wayne National Bank Bldg., Fort Wayne, IN 46802

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Laura Middleton has settled in the big city of Mount Ida, Ark. She graduated from the University of Michigan Medical School and completed a flexible internship at St. Joseph Mercy Hospital in Ann Arbor. She writes: "The highlights of my last year in med school were two months at the National Institute of Health in psycho-pharmacology and a month of neurology in a small neurological-neurosurgical hospital set in the Sussex countryside in England. I spent the weekend days exploring London and going to the theatre and generally marveling in the little things that make up the cultural differences.

"After that I spent three weeks traveling to Copenhagen, Vienna, Lausanne and Paris. In Lausanne I stayed with a non-English-speaking French-Swiss couple whose son had been my patient in England. It was terrific fun trying to express myself in high school French and German.

"Internship cannot possibly be described briefly except with a lot of expletives, exhaustion, despair, frustration, and anger, but lots of humor and satisfaction, too. I joined the U.S. Public Health Service National Health Service Corps and by a peculiar set of circumstances here I am in Mount Ida, Ark. Mount Ida is a town of 850 people (several thousand in the surrounding country). I am effectively a partner to two other G.P.'s in a small clinic 35 miles from the nearest hospital. It is beyond me why no one had yet volunteered for services in the mountains of Montgomery County with the surrounding recreational facilities: a 35-mile-long lake with 900 miles of shoreline, rivers, crystal mines, and diamond field. I have been waterskiing several times and have been here only three weeks.

"Work is fun and interesting, too. I have seen more poison ivy, swimmers ear, etc., than I saw all last year as well as the results of the more

delightful fauna: chiggers, ticks, copperheads, and cottonmouths. In this state pularomia and leptosperosis are not esoteric diagnoses! I don't know what my plans will be when I finish my two-year hitch; rural medicine may have acquired a very likely convert."

I hope that Laura continues in the rural areas. Perhaps her descriptive travelogue will attract some other classmates to rural medicine.

I received a letter from **Yoa Ah Poh** working for Mobil as Supply Associate in Kuala Lampur, Malaysia. He is enjoying it and has seen quite a few alumni in town.

Bill Swedish and his wife Linda are the proud (and surprised) parents of twins, Jennifer and Kristin, who were born on Feb. 12. Bill is still at MITRE in air traffic control analysis. Congratulations!

Paul Bannister is currently Marketing Manager for Hewlett-Packard and wants to hear from his classmates and fraternity brothers when they are in northern California. . . . **Thomas W. Muller**, M.D., recently completed his residency in anesthesiology at Walter Reed Army Medical Center and was appointed to the teaching staff at Walter Reed. . . . **Don Estes** has finally returned to New England and although temporarily in Ridgefield, Conn., plans to settle in Mass. to get a Ph.D. in clinical psychology. . . . **Thomas Sico** graduated from Ohio State University College of Law in Dec., 1977, and began practicing in April, 1978, at 427 West Eighth Ave., Columbus OH 43201. He was appointed educational counselor for the Columbus area last year. He is engaged to be married to Theresa Merva on August 25, 1979. . . . **Douglas Hough** is joining the American Medical Association in Chicago as a research associate. He is looking for **Larry Pleskot**. . . . .**Philip O. Martel** is working for General Electric and has acquired a Professional Engineer's license and a First Class radio telephone license. Phil plans to move into consulting in the long run. . . . **Rich Goldberg** is at Bell Labs in Holmdel, N.J. He and Linda are expecting their first child in September. . . . **Dan Weinberg** and his wife Page Laws (Wellesley '74) are pleased to announce the birth of their son Henry on May 6; Henry joins brother Garret, who is now almost two. Dan is with Abt Associates, Inc. as a senior economist. Page is completing her Ph.D. in comparative literature. One of their recent projects has been restoring a 25-year-old 13 1/2-foot wooden lapstrake sailboat, which they hope to have sailing by the end of the summer.

Thanks for all the news. Please continue to write — **R. Hal Moorman**, Secretary, P.O. Box 1808, Brenham, TX 77833

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Happy fall to you all. The doctors are on the move again. **Gail Thurmond** recently moved to New Hampshire. She finished her internal medicine residency and is now starting a neurology residency at Dartmouth. She has bought a nice old house in West Lebanon, and says, "Come visit!"

Dean G. Freedlander has completed his residency in psychiatry. He is continuing at Mt. Zion Hospital (San Francisco) in a child psychiatry fellowship. In addition, he has opened a private practice in San Francisco. **Larry Fisher** and his wife Laurie were in town visiting him from Denver, where Larry is finishing his residency in pathology. Dean notes: "For entertainment, other than just watching Larry be himself, John Eidinger, '75 and I spent most winter weekends skiing at Squaw Valley. John's doing well as an engineer for E.D.S."

In the marriage and children department, **C. Hafemann** married Cynthia Tremblay of Tewksbury, Mass., October 14, 1978. **Lynn** and **Seth Cohen**'s daughter, Rachel, was born on March 30, 1978. Seth is still working at Digital in Marlboro, Mass., in their large computer software engineering department. Lynn works for Digital, too, as a promotional writer.

Scott Brady completed a Ph.D. in cellular and molecular biology at the University of Southern California in September, 1978. He is presently a post-doctoral fellow in the Department of Anatomy at Case Western Reserve University. . . . **Richard Arratia** was hoping to graduate in the summer of 1979 from the University of Wisconsin. His thesis was on "Coalescing Brownian Motions." He then intended to go to the U.C.L.A. math department for two years.

From the world of business, **Hikaru P. Shimura** is back in Boston to run his business — instrumentation of scientific analytical instruments such as analytical X-ray, etc. His return address gives the company name as Rigaku/U.S.A., Inc. Planning ahead, he notes that in a few years, he will be going back to Japan again.

Stephen Glazier is now an attorney, in addition to being a civil engineer. His work may be of interest to some class members since he is arranging tax shelters and is a real estate investment syndicator in Houston.

Leslie M. Klein appears to be doing great in the north lands. She's somewhere in Ontario and the winner of the 1977 W. Gerald Raymore Medal of the Ontario Association of Architects, given to her in February, 1978. She joined the Ontario Association of Architects in April, 1978. In October, 1978, she took the big leap and established the firm of Leslie M. Klein, Architect and Planner. She is also a member of the board of directors of the M.I.T. Club of Ontario.

Stephen A. Chessin notes that he saw **Steven Henry** when in Boston in June. Steve Henry and Carol have twins! . . . **Duane Lindner** threw a small surprise party for **Lennie Pfister**. He is getting married. (By the time you read this he will be.) Also there were **Steve Schuster** (who showed slides of hiking trips), **Paul Magerl** and **George Pavel**'s brother Robert. George himself couldn't make it — he was in Hawaii. . . . **Bob Peterson** is supposed to be passing through as he hikes the Pacific Crest Trail, but I haven't heard from him.

Finally, **G. Rowland Williams** has changed his residence and employer from Waltham and Haemonetics Corp. to Cohasset and Codman and Shurtleff, Inc., where he is in charge of packaging systems for medical devices. . . . **Bill Roberts** is a fire control officer and overhaul manager for the *U.S.S. William V. Pratt (DDG-44)*, presently in Philadelphia Navel Shipyard for a year-long overhaul.

That covers the news. Summer is fast fading into fall. I got outside of the city a lot on weekends. I hope that you all had a good summer. Send me your latest news to share — **Wendy Elaine Erb**, 531 Main St., Apt. 714, Roosevelt Island, New York, NY 10044

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Hello again and thanks for the v.p. (veritable plethora) of letters greeting me this sunny day. **Dan Greenbaum** will head a new five-year program of the Mass. Audubon Society to handle environmental problems on Cape Ann. He will be handling a $500,000 grant for the program, recently donated by a local couple. The two-page clipping I received, however, never did get around to saying what the money would be used for.

Old friend **John Kiehl**, one of the better musicians the 'tute has produced, is involved in a recording studio in Boston as a technician, engineer, arranger and bassist. He has recorded jingles for a number of major concerns. Old Kappa Sigs can write c/o Soundtrack, 77 N. Washington St., Boston, MA 02114.

Susan and **Alan Lehotsky** have an active 3-year-old, Steven ('98), and are enjoying life. Alan is project leader for the VAX-11 BLISS compiler and a heavy traveler.

Perennial writers **Irv** and **Jean Paskowitz** delivered third son Thomas A. ('01) in March. They were both with Monsanto in St. Louis and active in the local M.I.T. Club. Irv received an M.B.A. in December, the pinochle of his college career.

William Stohl received his Ph.D. from Penn this year, and will also end up in St. Louis to start an internal residency at Barnes, along with wife and new daughter. . . . **Charles Johnson** and Ingrid have had two boys since leaving school. He is now doing project instrumentation and EE for Exxon in Benicia, Calif. **Peter Harris** is a process design/engineer in hybrids with Tektronix in Portland, Ore. He became father of a lad on April 19. . . . And **Doug Mink** survived an amicable divorce to return to Cambridge as a programmer seeking rings around Neptune for the E & PS people at M.I.T. . . . And, last but least, **Tony Scandora** became the father of a six-pound, two-ounce calzone (i.e., his girlfriend can finally cook Italian.)

Your friendly devourer of aforesaid calzone is an associate product manager for Electronics for Medicine in Dallas. Y'all write! — **Robert M. O. Sutton**, Secretary, 2005 Cedarwood, Carrollton, TX 75006

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It seems like ages since I last received a card or a letter from you. Why don't you write me? You don't even have to know me. Tell me your problems, your joys, where you get your money, and if your sister is going to be in town soon.

A while ago, (a time before I can remember) I received an anonymous packet of letters and notes from some of you. This is probably old news to many of you but I'm going to include it anyway. Besides, if you object, it will be too late. So there. Write your congressperson.

Kenneth V. Miselis (very formal) received his M.D. from the University of Vermont last May. Ken, please tell me what your specialty is: perhaps we can round up some classmates for you to experiment with. And **David Withee** has been promoted to the position of National Manager of Educational Materials for Junior Achievement Inc. in Stamford, Conn. This promotion was last May. But I'm sure he is still moving up the corporate ladder. Now **Fred Shapiro** gets the award for the most coherent news presented to me in written form so far. It is so readable, I am going to insert it here:

"**Bob Steingart** is working at DEC in Maynard. . . .**Mike Tangredi** is completing his Ph.D. in applied mathematics at Wisconsin. . . . Dave Lockwood '75, who began with our class, has been featured in *People* magazine, a U.P.I. story, four TV stations in New York and numerous other media outlets for his tiddlywinks exploits. He will undoubtedly be the first person associated with our class to make the *Guiness Book of World Records*. . . . **Dave Sullivan**, who missed election to the Cambridge City Council a few years ago by the ridiculous margin of eight votes, is running again this November, and would probably appreciate the votes of classmates (not to mention other alumni and their friends) who are registered in Cambridge. These are the only classmates with whom I am currently in touch."

Mr. Sullivan: if you are still thinking of running, please let me run your platform in this column. I know that many of your potential constituents look to this publication for moral and spiritual guidance. Opposing views will be presented at my discretion depending on the amount of outstanding principal on my school loans. Cambridge, your future awaits. (The corn keeps coming!). Remember those M.I.T. Alumni Fund envelopes that many of you sent in last summer? The ones with the space on the back for "notes on my activities for publication in *Technology Review*"? Well, here they are! Annotated! And expanded for your reading pleasure.

Eileen Siegel Frommer writes that she and Dr. Myron H. Frommer, '73, were married in January of 1974. They now have three children. They have been in Nottingham and Cambridge, England, and Philadelphia, Penn. It's hard for me to infer from the note, but I believe Eileen and Myron are still in Philly. Help me out, Eileen. Are you still looking for a part-time job? I hear that the Carter Administration is looking for people.

Barry Zack is at Index Systems in Cambridge, a management consulting firm. His wife Linda (class of '76) works for Sanders Associates in Nashua, N.H. Their daughter, Robin, was one year old as of June 16, 1979. . . . Another Harvard Business School graduate has entered the world of management consulting with Booz Allen and Hamilton in Atlanta, Georgia. **William Stargardt** is his name. Send him your resumes. . . . **Gary Miyashiro** got

his M.B.A. from Wharton and is now working for Arthur Young and Company in Stamford, Conn. He is married to Rose Marie Tamura (a graduate of Smith College) since 1977. . . . **Andre (Drew) Jaglom** is still practicing law at Paul and Weiss in N.Y.C. He is enjoying rugby, softball, and the Big Apple. And as of May, he became engaged to Janet Stampfl whom he met in the Harvard Law School show.

Now for some older news. This is almost time machine stuff for some of you. If I'm out of date I hope you'll let me know. **Ted Kochanski** (you all remember Ted) writes that **Richard Webb** returned from the solo conquest of a 20,000 foot hill in Nepal to be the best man for Ted's marriage to Christine Landry Murphy on December 16th in Austin. The pretest research Tokamak he is working on is also progressing. It sounds like you're still batting one thousand, Ted. . . . **John Black** will have finished his Ph.D. in materials engineering this summer. (The problem with old news is that I feel very insecure about it. It's like teaching the history of Mars: I'm not sure if I've got the right facts.) . . . **Barry Nelson** expected to receive his Ph.D. in chemical physics in September. His thesis is on "Vibrational Spectroscopy of Glasses." That seems to be fairly clear.

Vivian Loftness (as of March 5th) is a project manager at the American Institute of Architects/Research Corp. and is involved with passive solar programs such as preparing design guidelines and calculations for designing energy conserving, passively heated and cooled buildings. . . . **Mark Mazak** has returned to Boston and is a senior planner for the Determination of Need Program in the Mass. Department of Public Health. Clearly, this Commonwealth is in great need of health. Everyone I know says that we live in a sick society. Good luck, Mark. . . . **Scott Schecter** says that he will be marrying Leslie Rosenthal, '78, on July 1, 1979. He is currently with Bain and Co. in Boston. . . . **Elizabeth Newton** has transferred to Tufts Medical School from Medical College of Pennsylvania and will be a member of the Class of 1980. . . . **Arnold Schiemann** writes: "Last October I was appointed (by the President of the Republic) head of the Systems Division at the Department of National Planning. As a part of my job, I am also heading the National Computer Commission. On April 8th, I got married to Clarita Cadena." Congratulations to you Arnold but I don't know where you are. Let's hit that in the next column.

Greg Turner is working for Philip Johnson and John Burger, Architects, in New York City on the new A.T.&T. Corporate Headquarters Building. . . . **J. Alan Ritter** has graduated from Washington University in St. Louis with a M.S.E.E., May '78. He is now working in St. Louis developing EKG monitoring systems. . . . **Donna Shoupe** is the resident physician for obstetrics and gynecology at Women's Hospital in Los Angeles, Calif. . . . **Mark Fischler** has received his Ph.D. in physics from Stony Brook and is working as a research associate at Fermilab. In July, he married Susie Robbins. . . . Last spring, **Leonard Davis** received his Ph.D. in organic chemistry from U.C.L.A. He is currently employed as a senior research chemist at Monsanto's Rubber Chemicals Division in Akron, Ohio. . . . **Shera Stern** is doing her residency in internal medicine at Maimonides Hospital in Brooklyn.

Larry Eisenberg and **Chris Eidsor Eisenberg** had a 7 pound 5.5 ounce son (Eric Christopher) on July 20th, 1978. Larry is still working as a budget analyst for the Wisconsin Department of Administration while Chris is at home "enjoying mothering." . . . **William Young** is currently flying high as a pilot with the U.S. Air Force at Shaw A.F.B., South Carolina. . . . **E. P. Shareck, Jr.** is "living in a closet in Santa Monica, spending free nights in Hollywood at the Rainbow Bar and Grill when not interning at Cedars-Sinai Medical Center." He will receive the Patty Hearst award for the culinary and medical performing arts. . . . **Rory J. Albert**, since his graduation from Columbia Law School, has become associated with the Manhattan law firm of Proskauer, Rose, Goetz and Mendelsohn and is specializing in labor law. . . . **Ralph Nauman** says it all and I have the privilege of quoting him here: "Five years out of M.I.T., I remain completely dazed and confused. I'm writing a book about it, which may help." I believe that Ralph speaks for many of us.

We are now officially caught up on the news notes. Much of the foregoing may have been incorrect. The fact that good penmanship is not an Institute requirement is increasingly evident to me. I will be happy to publish retractions.

Now on to the current news! (This really means the stuff that was only recently processed by the Alumni Fund folks — it's mostly from last June.) **Stan Young** says that Jasmine (his wife, I think) received her master's degree in urban planning last summer. He is finishing up his Ph.D. in chemistry and then going on to a post-doctoral position at Cornell. . . . **Paul Schindler** has gravitated to a new position. Paul, formerly a business reporter for the *Oregon Journal* in Portland, Oregon, has been appointed West Coast editor of *Computer Systems News* (a 9-month-old biweekly newspaper which covers the original equipment manufacturer (OEM) and systems house segments of the computer industry). . . . **Don Higgins** (finally, I know where you are) has settled in Pine Lake, Georgia and has a son, Jesse, who was born in April of this year. Our class is certainly coming up with babies. Congratulations to all of you. The hard stuff is after the baby is born. . . . **Rick Belejack** has just finished up a month-long vacation in Scotland and England and I hope he will write in and share some of it with us. . . . **Esther Hu** is completing her Ph.D. in astrophysics at Princeton and then taking up a postdoctoral fellowship in Washington, D.C. this fall. (Note to Esther: your suggestion for more deliberate decision-making with regard to undesignated funds comes at a very opportune time. I will try and get more info together.)

Last March, **David Shiang** self-published *On the Absence of Disorder in Nature* for the Einstein Centennial. . . . **Raymond Van Houtte** says that he has "sold out!" and is now working for Motorola near Baltimore in the exciting field of programming. Hell, I do it too. It's a living. . . . **Michael Chang** received his D.M.D. from B.U. School of Dentistry. He is encouraging everyone to say "cheeseburger." . . . **Joanne Lyons** has taken her business to Acorn Park in Cambridge and now belongs to the mighty minions of Arthur D. Little, Inc.

That's all of it. It's now 3 a.m. Hurricane David is going to breeze through here in a few hours and probably put some water in my basement. I can wait. Now I want to hear from some of you. The first column I wrote just hit the stands this past week. Reaction has been succotash, or mixed, as some people say. I don't mind printing what ever you want to say. I'm tough: I can take it. After all, I lived in H-Entry and had to share the bathroom with fifteen other people, most of whom were ruthless transients from women's colleges in the area. Yeah. Real tough.

Anyway, *Playboy* magazine always wants to tell you what's coming up in the next issue. I think I will adopt this technique to your disadvantage. We (Lionel and/or I) will report on our binges at the Alumni Officer's Conference being held late in September. The inside, in-depth, insinuating, inappropriate story of the ins and outs of Denver may appear on these pages. Also, the words to our School Song so you can learn them and impress your friends. I'm going to knock this off and get some sleep. (Applause.) Oh! One more thing: how many of you drive Austin Marina or 1973 VW buses? Tune in next time for the answers to this question. The Rumor of the Month is that Ludwig Chang is moving over to Chase Manhattan Bank and is leaving NBC for a challenging executive position. That's all, folks. Register to vote. — Co-secretaries: **Jim Gokhale**, 6 Burton St., Arlington, MA 02174; **Lionel Goulet**, 34 Tremlett St., Dorchester, MA 02124

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Here's the news. **Henry Heck** writes: "After three moves in a year and a half, I'm happy to have spent two and a half in one place. Greetings to the Bombers of Burton 3rd. Look me up in the Oakland directory if you're coming out this way." . . . And from **Marshall Burns**: "Although I finally graduated in June, 1979 (S.B., physics), I still feel more like a member of my original class. So far, my M.I.T. degree has brought me the great privilege of turning down a $20K/year job in the IM complex. I am now busy putting together a nightclub act wherein I will sing, dance, and make merry. It makes life almost worth living again. Regards to all my fellow M.I.T. expatriots." . . . **Sue Tsang** worked for more than three years and returned to graduate school this fall in the Department of Pharmaceutical Chemistry at the University of California, San Francisco. . . . **Greg Rothman** graduated from N.Y.U. School of Medicine and started his internship at Lenox Hill Hospital on June 29, 1979. According to Greg, "The party's over."

We have three weddings to extend our congratulations on and that will just about wrap it up for this time. **Brenda Blake Schilinski** was married on February 10, 1979, to Paul B. Schilinski of Houston, Penn. Brenda is stationed at Ft. Warren A.F.B., Wyoming, as a geodetic officer. . . . **Stewart Johnson** was married in April to Jane Kestenbaum (a Barnard grad). Otherwise, Stewart is "still struggling to finish my doctorate in microbiology at Duke." . . . **Dave Kelly** says, "All sorts of good news: I joined the debtor's class when I bought a house in West L.A., and I have married a lovely lady (and a great dancer) named Deborah Yossem in January. . . . like all us scoundrels, she works in the computer business."

O.K., folks, keep in mind that our fifth reunion is approaching this June. Start planning to come back to Beantown now.

As always, I love to get mail from you. — **Jennifer Gordon**, 22 Centre St., No.9, Cambridge, MA 02139

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Let me apologize in advance for the brevity of these notes.

From the mails: **Wayne Hamburger** writes that he is working as a computer performance analyst for General Dynamics' Western Data System Center in sunny San Diego, Calif. He is responsible for measurement of performance and tuning of a large I.B.M. 370 installation. "I am active in all the typical southern California recreations — motorcycling, tennis, raquetball, beaches and women!"

Gikas Mageras received an M.S. in physics at the University of California at Berkeley in 1978 and is presently working on a Ph.D. at Columbia. He is a graduate research assistant on the Columbia/Stony Brook electromagnetic shower detector experiment, to be run at the Cornell electron storage ring (C.E.S.R.).

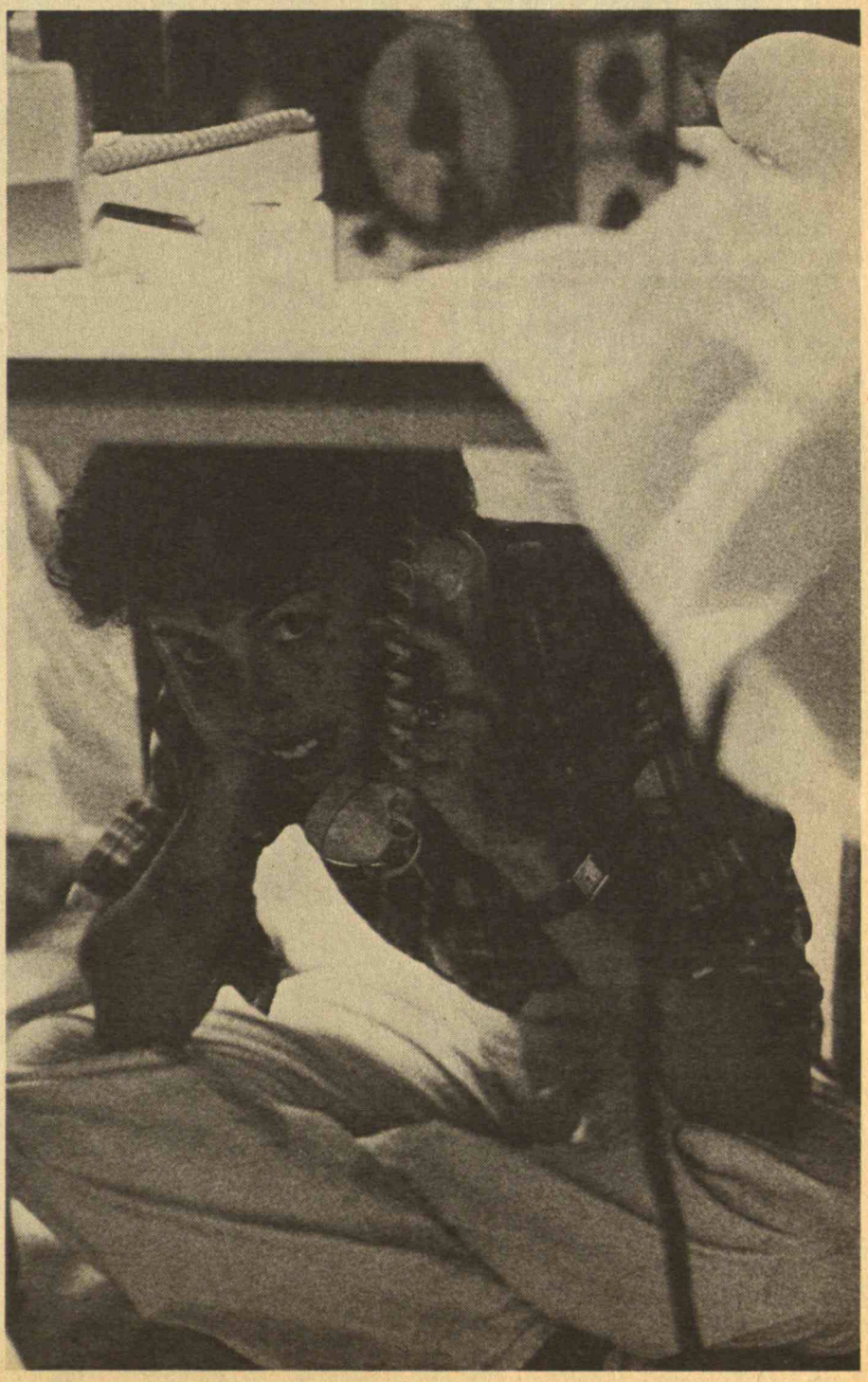
Sam Price is still in the Army and is presently attending a computer systems school at Ft. Benjamin Harrison in Indianapolis. After finishing, he will go to a project group in San Antonio, Tex. Sam married Kathy Shriver from San Jose, Calif., on April 14, 1979.

Gary Buchwald has changed jobs and is now with Analogy Devices in Norwood, Mass. His wife Michelle (Gershman, '79) is now an actuary at John Hancock. Gary and Michelle have moved to Sharon, where they have purchased a lot and are in the process of building a house. (New address: 97 N. Main St., Sharon, MA 02067.)

Your secretary has continued in his offbeat ways due to the price swings in the commodity markets. Gold, silver, platinum, and "pork bellies" have been making amazing price advances since the last issue of *Technology Review*. The larger the price movements, the wilder the time we have here. This is definitely not a business for the nervous or slow of wit. What we have is crazy markets and an amazed (and sometimes dazed) secretary!

Please write so that we may have more news — or I may be forced to regale you with tales from the pork belly and cattle futures trading pits. — **Arthur J. Carp**, Secretary, Endymion Commodities, Inc., 131 State St., Suite 616, Boston, MA 02109

What's it like at M.I.T.? For students who wanted to help their parents understand, the Alumni Association offered a one-minute free long-distance call to the folks at home from the "Activities Midway" during orientation week. Trying to escape the surrounding hubbub, this freshwoman made her call from under the table. (Photo: Mark Sloan, '81, from Technique)



Remember When You Came to M.I.T.? Adminstrators Offer Advice

Freshmen have a lot to absorb upon arrival, dwarfed by M.I.T.'s imposing pillars and intimidating reputation. To assuage initial fears and lesson confusion, newcomers were offered a sketch of academic programs — and some general wisdom — by a panel of M.I.T. administrators and faculty last September. A sample:

"Be the organizer of your own education," counseled Walter A. Rosenblith, Provost. "Take advantage of what is here, and keep an open mind about where you want to end up."

He said the map of science and technology will change dramatically in the next 50 years, and students must have tolerance for the changing of that map. And he talked of the development of M.I.T., its leaders (such as Karl Taylor Compton who reaffirmed the importance of science to technology and created the School of Science), and its increasing recent emphasis on interdisciplinary fields — "problems in nature and society don't always come labeled by department.

"Knowledge is growing faster than the economy, human needs are growing faster than knowledge, and wisdom is growing slowest," said Professor Rosenblith. "The world out there needs your contribution."

Robert A. Alberty, Dean of the School of Science, talked about the philosophy behind the freshman curriculum: "A part of early experience at M.I.T. should be not to just provide facts, but to see how scientists look at the world, what they value, and how they solve problems."

And Harold J. Hanham, Dean of the School of Humanities and Social Science, suggested that freshmen ask themselves "What am I going to *need*? Do you think you write so badly that you need help? Or do you write so well, you should write for the *Globe*? We can help both."

Professor Rosenblith alluded to the problem of writing. We don't teach a lot of exotic foreign languages at M.I.T. any more, he said; "we're happy if students can speak and write English." — *M.L.*

"Feeling out" M.I.T. and learning about one's classmates are among the unofficial preoccupations of orientation week at the start of every fall semester, and the Class of 1983 made both of them look like fun last September. When it came to the more serious business of deciding where to live, the class leaned toward on-campus housing: the fraternities went into rush week hoping for 416 pledges but came out with only 397 new residents – by no means a disastrous short-fall but serious if it represents the beginning of a trend. (Photos: William D. Hofmann, '80, and Mark H. Sloan, '81, courtesy of Technique; *and Calvin Campbell, M.I.T. News Office)*

The Class of 1983: More Applicants, Bigger "Yield," Fewer Women

With the Class of 1983 settled in, a look at some figures:

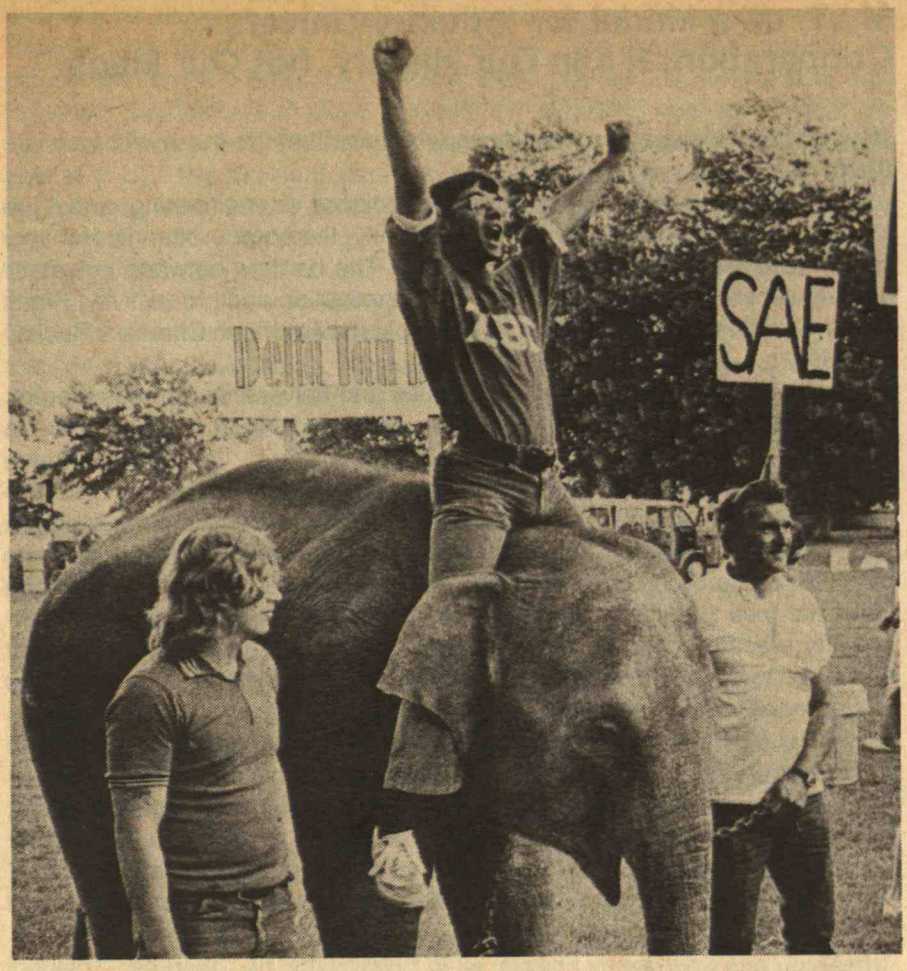
Total registration is 1,070, somewhat above the target size for the class established by the Faculty Council last spring. There were 5,300 final applications, from which the Faculty Committee on Admissions picked 1,812 to be admitted. The "yield" is thus up to nearly 60 per cent — a gratifying increase.

The freshmen came to M.I.T. from 47 of the 50 states — with the Middle Atlantic area providing 35 per cent — and from 24 foreign countries.

They prepared for M.I.T. at 693 public high schools, 149 independent or church-related schools, and 63 foreign schools. Over 80 per cent were in the top tenth of their classes, and almost half entered M.I.T. with some college-level credits.

The oldest member of the class will soon be 24, and the youngest is 15. One is the fourth generation of his family to attend the Institute.

Twenty per cent of the class are women — down a little from recent years; and 10 per cent are minority — blacks, native Americans, or hispano-Americans.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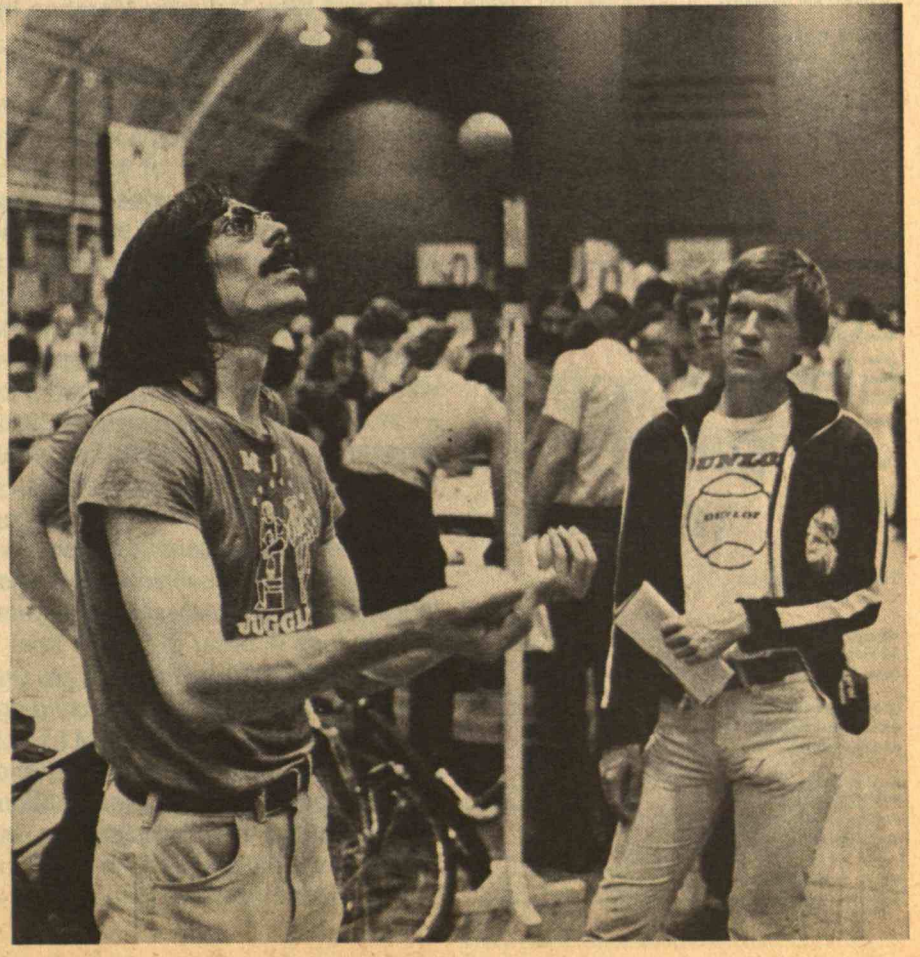


M.I.T. as a Model for Industry-University Cooperation: It's in Our History, not Our Magic

How do good ideas move from those who have them to those who can use them?

If the good idea is in some field of science or engineering, and if the former is a professor and the latter a company, the answer often is: Not very well. And that's bad news for the country. The barriers between university and industry are one of the thorns in U.S. innovation and productivity, Frank Press, the White House science adviser, told the American Chemical Society this fall.

The basic problem is that industries and universities are so different. "Industry looks at the bottom line while we are looking at teaching and the generation of knowledge," Thomas F. Jones, Jr., Sc.D. '52, told the House Subcommittee on Science, Research, and Technology last spring. The two systems have very different values, and when they confront each other on how to finance research and use its fruits, the two different value systems may turn out to be pretty intractable. Mr. Jones recalls the statement of one industrial vice president during 15 months of negotiations on an M.I.T.-industry research contract: "What are you talking about? You guys are not supposed to get any money out of this anyway" — a remark which Mr. Jones characterizes as "insensitive."

But Mr. Jones insisted that in the long run he is optimistic: "We have to work out our differences, and we will," he told the subcommittee.

Representative George E. Brown, chairman of the subcommittee, picked up on the issue. M.I.T. has "a better record up there than any other school that I know of . . . on this problem of industry-university cooperation," he said; and he asked Mr. Jones if there wasn't some "magic" he could share.

How and Why Industry Marches in Our Doors

Mr. Jones turned that question over to Samuel A. Goldblith, '40, vice president for resource development, who made his own appearance before the subcommittee two months later. For nearly an hour Professor Goldblith — he was formerly director of M.I.T.'s Industrial Liaison Program — described M.I.T.'s "extensive linkages" between M.I.T. and industry — "indications and illustrations," he said, "of the directions in which we can proceed in our national effort to increase innovation and productivity." On Professor Goldblith's list:

☐ Industrial Liaison Program and M.I.T. Associates link the Institute with 186 larger and 48 smaller firms, respectively. The idea is "to provide companies with easy access to the state-of-the-art in M.I.T. laboratories and classrooms — 'a window on technology of the future'," said Professor Goldblith. The programs include individual industrial-faculty visits, symposia, and publications, all facilitated by a full-time staff at M.I.T. fully committed to the task. No other educational institution has a comparably large industrial liaison effort.

☐ Cooperative research programs which "integrate critical support from industry" on major technical problems. The obvious example is the M.I.T.-Industry Polymer Processing Program, to which 12 industrial firms pay membership fees in order to benefit from M.I.T.'s "broad research and development capabilities" in the field. A similar program is now in the formative stages in the field of manufacturing productivity, and there are substantial industrial inputs of this type to M.I.T.'s Energy Laboratory and Chemistry Department, in toxicology research, and in system dynamics and information systems research in the Sloan School of Management.

☐ Cooperative teaching programs, in which students spend time in industry solving industrial problems for academic credit, include two of the oldest and strongest such activities in the nation — the cooperative program in electrical

engineering and computer science and the School of Chemical Engineering Practice *(see March/April, 1979, pp. A20-23).* Now there is a growing Engineering Internship Program in all engineering fields. The central idea, said Professor Goldblith, is to place students in "rewarding 'real-world' work assignments that extend the learning experience into areas that are not available at M.I.T." (No accident, perhaps, that in 1978 28 per cent of M.I.T. S.B.-degree recipients, 42 per cent of S.M.S., and 25 per cent of doctorates went into industry upon graduating.)

☐ A significant part of the Undergraduate Research Opportunities Program (U.R.O.P. —*see October, 1979, pp. A2-8*) takes place off the M.I.T. campus. Students are working at some 50 outside organizations — industries, hospitals, government agencies, museums; and for all the undergraduates who take part — more than half the total enrollment, said Professor Goldblith, U.R.O.P. is "a unique, proven means of 'teaching' innovation by 'hands-on' experience."

☐ For practicing engineers, M.I.T. teaching programs are made available through the Center for Advanced Engineering Study (C.A.E.S.), the source of "new approaches to continuing education."

"An Incredibly Positive Intellectual Ferment"

But the secret of M.I.T.'s success is more a matter of attitude than of programs, Professor Goldblith told the subcommittee. The important thing is a commitment by faculty and administration "to actually take time to become personally involved in collaborative work on an ongoing basis. . . . Face-to-face exchange . . . is what provides the real energy to these programs."

In Dr. Goldblith's judgment, M.I.T.'s success with industry goes back to the very beginning — an "early and continuing orientation toward both the theoretical and the practical aspects of knowledge.

"A cooperative, mutually supportive, and interactive relationship with industry (has been) an integral part of its mission in teaching and research." Industrial consulting and public service have been seen as "positive" faculty attributes; indeed, Professor Goldblith said, "faculty consulting and entrepreneurship are integral parts of the M.I.T. environment." A study by Professor Edward B. Roberts, '57, shows 150 companies spawned by faculty and employees of only seven of M.I.T.'s many laboratories, and alumni of the same groups have spawned many more.

(On other campuses it may be very different. Emil Mrak, retired chancellor of the University of California at Davis, complains that "close contact with the private sector has come to be seen as a negative thing" on many college campuses. At a session this fall in tribute to Professor Goldblith, Dr. Mrak bemoaned the "shaky bridge between universities and the private sector. . . I think it is desirable for a professor to be on the board of directors of a company, or at least to be a consultant," he said.)

Some other advantages for M.I.T.'s industrial relations:

☐ Interdisciplinary laboratories are strong here. "We not only allow work that goes beyond traditional academic disciplines, we applaud and foster it," Professor Goldblith said; and he thinks that's important because "industry's — and the world's — problems do not honor disciplinary boundaries."

☐ There is "a great deal of intellectual flexibility and responsiveness, . . . a senior administration that is committed to the generation of activities and ideas."

☐ Education is a matter of both teaching *and* research, and "I think this integration on all levels leads to a special, incredibly productive intellectual ferment which industry senses and wants to tap into."

☐ M.I.T. is more than an engineering school, contributing techniques and processes important to industry now. "Our science and management skills mean that we also have a big contribution to make to industry for the future."

— *J.M.*

The Editors Ask You to Look Again

The picture was the star of the issue, the event the hit of the week-end. But we blew it.

For *Technology Review* assigned the entrepreneurship leading to the appearance of this professional dancer at an M.I.T. reunion last June to the Class of 1954.

Not so.

The party which attracted *Technology Review*'s photographer and left an unending impression of modernity in M.I.T.'s Historical Collections was the gala of the *20*-year reunion of the Class of 1959. By its error the Review has aggrieved the Classes of 1954 *and* 1959 — and perhaps some other readers as well, and we hasten to correct the record. — *J.M.*

$1.45 Million from Sea Grant: But Not Enough Engineering

Just over $1.45 million will come to M.I.T. from the Office of Sea Grant in N.O.A.A. during the current (1979-80) fiscal year. It's the eighth grant to the Institute's Sea Grant College Program — and, in accordance with Sea Grant terms, the total for M.I.T. research and advisory services will be nearly doubled by matching grants, many of them through the Marine Industry Advisory Service Collegium.

The Sea Grant funds will support a wide range of science, technology, and policy studies at M.I.T. — offshore structures, underwater vehicles, environmental management, and ship design. They come to the Institute just a year after Alfred A. H. Keil, Ford Professor of Engineering, called for increased Sea Grant support for ocean engineering and technology activities.

"Modern ocean science is only possible, and becomes most effective," Professor Keil told the Sea Grant Association late last year, "with the use of modern instrumentation and techniques. . . . I see the need for a systematic approach to ocean engineering aimed at advancing nonmilitary uses of the oceans. . . .

"Since there can be virtually no ocean use without ocean industry, it follows logically that the National Sea Grant Program should emphasize links to, and cooperation with, industry."

WTBS Is Now WMBR, with 200 Watts to Reach Route 495

Big things at WTBS, M.I.T.'s student-operated radio station:

☐ As of May 1, it suddenly changed its call letters. Listen now for WMBR at 88.1 FM.

☐ As of sometime this fall, its power will jump from 10 watts to 200 watts, the difference between a Class D and a Class A license. Listen now anywhere in the Greater Boston area, all the way out to Route 495.

The two changes are connected through R. E. Turner, III, owner of WTCG-TV in Atlanta — and also of the Atlanta Braves. Mr. Turner wanted the call letters WTBS for his Turner Broadcasting System. He paid the M.I.T. station $25,000 for them — and will pay another $25,000 when (and if) the Federal Communications Commission approves the change.

Mr. Turner's $25,000 put the station well on the way to financing a 200-watt transmitter and transferring from Class D to Class A. Only one catch: the new Class A license obligates the station to develop a minimum of 20 hours a week of public affairs broadcasting within a year. But Anita McFadden, WTBS — oops, WMBR — public affairs director isn't worried. "There already exists a solid base of public affairs programming on which to build," she says, "and there's a special effort to develop more programs of interest to the M.I.T. community."

The new emphasis was obvious as the term opened, when there were direct broadcasts from the Activities Midway, from Briggs Field, and from Dupont Gymnasium on registration day. Interviews with freshmen, live and on tape, were featured through-out orientation week.

Individuals Noteworthy

Rising and Changing in the World of Business

H. Stephen Spacil, '52, appointed General Electric Research and Development Center's scientific representative for Asia. . . . **David L. Littman,** S.M. '66, promoted to vice president and senior economist at Manufacturers National Bank of Detroit. . . . **James Rumbaugh,** '67, appointed manager of the Mathematics and Software Engineering Program at General Electric Research and Development Center. . . . **Joseph L. Veranth,** '69, appointed vice president of engineering for Bose Corp. . . . **Walter H. Berninger,** '63, appointed manager of the Appliance Control Program at the General Electric Research and Development Center.

Alfred B. Booth, '41, named executive vice president and senior consultant of Production Sharing International. . . . **William E. Harper,** '47, former staff executive of the Greater Providence Chamber of Commerce, has established a new management consulting group called Aztec Associates. . . . **Charles J. Henry,** '55, named president and chief operating officer of the Chicago Board Options Exchange. . . . **John K. Castle,** '63, named managing director of Donaldson, Lufkin and Jenrette, the securities-firm holding company.

Murray F. Gardner, 1898-1979

Murray F. Gardner, S.M. '24, professor emeritus of electrical engineering whose career at M.I.T. spanned 43 years, died August 4 in Canandaigua, N.Y.

When he first came to M.I.T., Professor Gardner was associated with the late Vannevar Bush, '16, and he succeeded Dr. Bush as head of the department's Research Division; he won an international reputation in the field of circuit analysis.

But Professor Gardner's principal dedication was to teaching. He was the author (with John L. Barnes, '28) of *Transients in Linear Systems,* and he taught a course of that name for 30 years until his retirement in 1963. As the department's graduate registration officer beginning in 1930, Professor Gardner had a major influence on the education of graduate students whose number increased from about 70 to over 500 during his tenure.

Professor Gardner came to M.I.T. for graduate study in 1920, having received his B.S. in that year from the University of Michigan; his teaching career began as an instructor in 1923, and he joined the faculty in 1929.

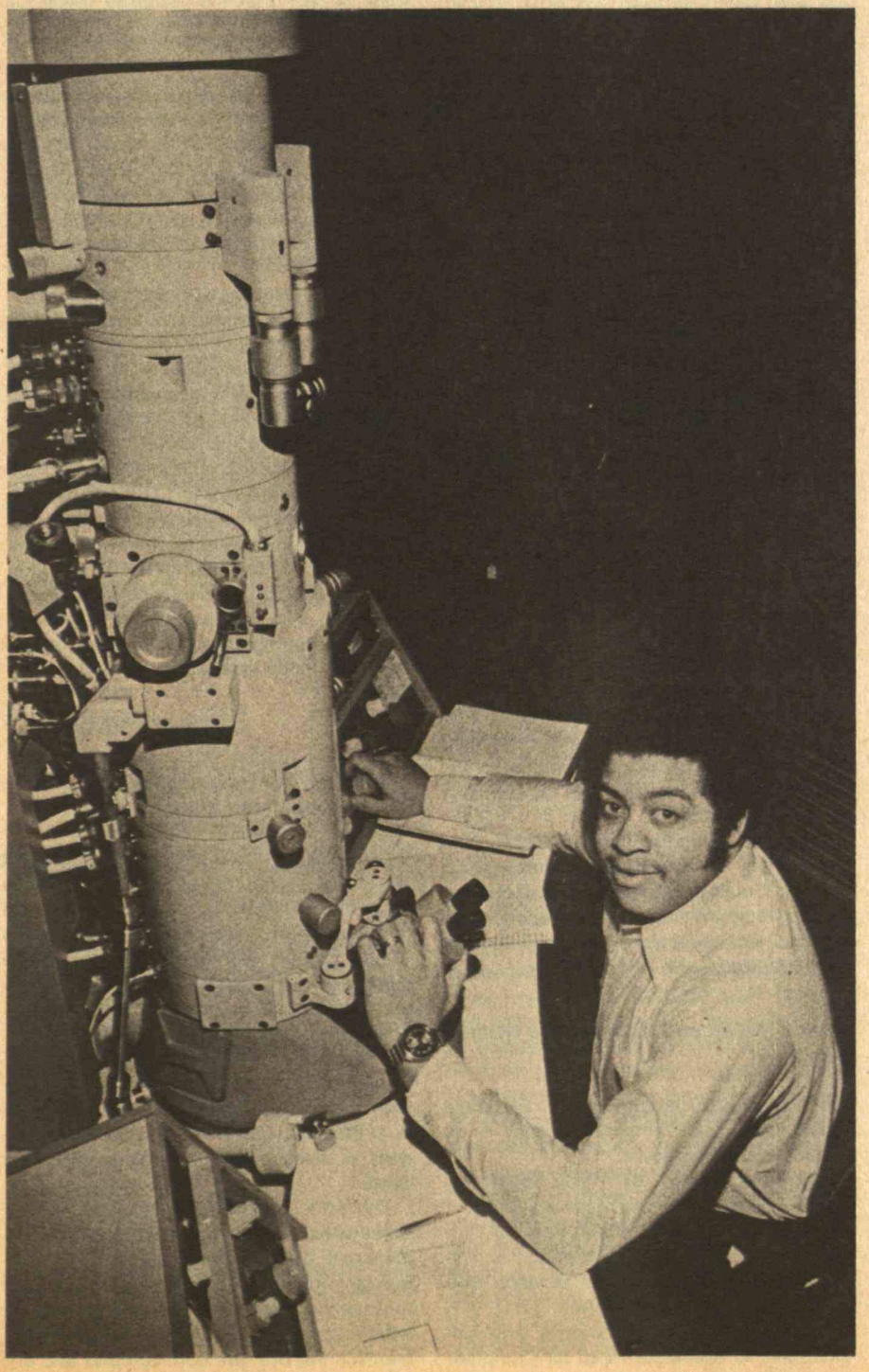
Theodore A. Mangelsdorf, 1903-1979

Theodore A. Mangelsdorf, '26, retired executive vice president of Texaco, Inc., who was president of the Alumni Association in 1966-67 and a member of the M.I.T. Corporation from 1962 to 1967, died at his home in Cumberland Farm, Va., on August 23; he was 76.

Mr. Mangelsdorf studied chemical engineering at M.I.T. and joined Texaco, Inc., immediately upon receiving his master's degree in 1929; he rose steadily within the technical branch of the company to posts of increasing responsibility.

While a member of the Corporation, Mr. Mangelsdorf served on its Executive Committee from 1964 to 1966; he was also a member of several visiting committees and of the Corporation's Development Committee. Meanwhile, as an active member of the Alumni Association, he became a principal architect of the M.I.T. Alumni Center of New York. He is honored by the Theodore A. Mangelsdorf Fund at M.I.T., established by the Brookdale Foundation of New York City to endow undergraduate scholarships.

Mr. Mangelsdorf is survived by two sons, Theodore A. Mangelsdorf, Jr., '51, vice president of Westinghouse Hanford Co., and Frederick E. Mangelsdorf, S.M. '60, who is associated with Texaco.



From Magnolia, Mississippi, to an M.I.T. Ph.D.: Breaking the Stereotype Barrier

"Even in the first grade I wanted to become a doctor. . . . But a black kid from Magnolia, Miss., isn't supposed to amount to much."

Jerry Lee Bryant, Jr., *has* become a doctor — the second black in history to receive a Ph.D. in biology at M.I.T. He'll continue his research — how chemicals kill viruses — through the summer, and for the fall he wants a university teaching job where he can do work which he thinks could lead to designing new drugs to alleviate virus infections.

Thinking back, Dr. Bryant remembers that "the idea of helping sick people to get well" appealed to him in even his earliest school days in Mississippi. Then, in high school, he started thinking about medical research: "After all, someone has to find out what makes people sick before doctors can help them," he reasoned.

While this was going on, Dr. Bryant became a good saxophone player — good enough to claim a music scholarship in Mississippi Valley State University, Itta Bena, Miss., where he majored in biology, met and married his wife Earnestine, and earned summer fellowships to Brookhaven and Argonne National Laboratories.

It was in 1971 that Dr. Bryant made his way to M.I.T. — with trepidation: "I knew it would be hard," he remembers, "but I felt that I worked ten times as hard as everyone else. . . . In the beginning I thought there was just too much — that I couldn't span the gap." But Professor Jonathan King turned out to be "very supportive," Earnestine went to work teaching music in the Cambridge schools, and "finally things began to fall into place."

"I was never discouraged from being ambitious," says Dr. Jerry Lee Bryant, Jr., "but I know most people didn't expect I'd do any of things I hoped to." They were wrong: Dr. Bryant is now the second black in history to receive a Ph.D. from the Department of Biology, and his success story makes nice reading.

I
Civil Engineering

Paul F. Rice's, S.M. '47, title is now vice president, engineering. He writes that his responsibilities include writing the C.R.S.I. handbook and computer programs for reinforced concrete design; he also holds design seminars — six-hour seminars in 28 cities for structural engineers; and is industry rep on the A.W.S. structural welding code and several other committees. He's the coauthor a book in the field: "Structural Design Guide to the A.C.I. Building Code." . . . On June 1, **Donald C. Taylor,** S.M. '56, relocated his office to the Hampden Center in Englewood, Colo. His business name is Donald C. Taylor and Associates, Construction Industry Research. . . . **Michael H. Zalewski,** S.M. '71, is a partner in A.E.A. Investors, a private investment company that purchases controlling interests in domestic companies.

William P. Donnelly, S.M. '68, is spending two years on the Philippines as senior activity civil engineer for the Navy Public Works Center. . . . **Stanley M. White,** C.E. '76, has just returned from five weeks in Denmark where he was supervising a hydraulic model test of a breakwater/harbor system at the Danish Hydraulic Institute. . . . The American Consulting Engineers Council has elected **Charles C. Noble,** S.M. '48, as a fellow. Mr. Noble is executive vice president of Chas. T. Main in Boston.

IV
Architecture

Charles C. Lozar, M.Ar. '65, writes that he has been heavily involved in government research in building design as it relates to environmental psychology. He focused on apartment and office design, using attitude studies to determine space, layout, and character. . . . **Adrienne Albert Brecher,** M.Ar. '74, is a partner in a Toronto-based marketing firm specializing in real estate. . . . **Robert L. Ziegelman,** M.Ar. '59, has lectured in Rio de Janeiro, with a group from M.I.T., on industrial building techniques. Mr. Ziegelman has a private practice in Michigan, and is an adjunct professor of architecture at the University of Michigan, as well as guest lecturer at M.I.T. . . . **Francis G. Whitcomb,** M.Ar. '64, has been elected president and chief operating officer of C.M. Constructors/Managers.

VI
Electrical Engineering and Computer Science

Monson H. Hayes, Jr., S.M. '49, has been appointed president and chief executive officer of

G. L. Wilson

J. Moses

R. B. Adler

Studying Tomorrow Today

"The future must be our most important focus for life. In contrast to the past, the future presents real threats to our survival. . . . Fortunately, however, much of the change of modern life is under human control, if we only exercise such control and exercise it intelligently."

The quotation is from the prospectus for Technological Society 2000, a course at Southeastern Massachusetts University in which **Siegfried M. Breuning,** Sc.D. '57, "uses the future as a 'thinking goal,' with technology seen 'as a vehicle to carry out that thinking,' " writes David H. Kogut in the *New Bedford Standard-Times.*

Dr. Breuning — he's Professor of Civil Engineering at S.M.U. in North Dartmouth —told Mr. Kogut that students are supposed to "think their way through the course, emphasizing two directions which a 'traditional education' fails to explore — teamwork and self." Working in small groups, they pick a technology they want to study for its scientific and sociological implications — energy, urbanization, ecology, space, communications, even American culture.

In such a team they learn how to work together while they try to understand their subject and themselves, their strengths and weaknesses, their desires and expectations for the year 2000.

Professor Breuning's class draws students from all levels and disciplines at S.M.U.; it culminates in a series of final reports by student teams in the presence of a "jury" of local educators, civic leaders, and private citizens who ask questions.

Wilson, Adler, and Moses at the Helm in Course VI

M.I.T.'s largest department — Electrical Engineering and Computer Science — is under new management.

Gerald L. Wilson, '61, Philip Sporn Professor of Energy Processing, is now Head of the Department; **Richard B. Adler,** '43, Professor of Electrical Engineering, is Associate Head for Electrical Science and Engineering; and **Joel Moses,** Ph.D. '67, Professor of Computer Science and Engineering, is Associate Head for Computer Science and Engineering.

Professor Wilson will continue as Head of the Electric Power Systems Engineering Laboratory, but its day-to-day operations will be in the hands of Professors Fred C. Schweppe and John G. Kassakian, '65, and Dean A. Powers, E.E. '51, Administrative Officer. Professor Moses leaves his post as Associate Director of the Laboratory for Computer Science to take the departmental assignment.

Professor Wilson, who succeeds Professor Wilbur B. Davenport, Sc.D. '50, as Head, has been at M.I.T. ever since he first came as an undergraduate in 1957. He joined the faculty after completing two graduate degrees (S.M. 1963, Sc.D. 1965), became Director of the Electric Power Systems Engineering Laboratory in 1971 and Philip Sporn Professor in 1973, and through much of this period has led M.I.T.'s growing involvement in power system engineering.

Professor Moses is considered one of the nation's leading theorists among computer scientists, and Professor Adler has made important contributions in electronic materials and more recently in biomedical engineering.

The Policy Contrast Between Oil from Sand and Shale

Oil shale resources of the Western U.S. and tar sands resources of Western Canada have lots of similarities. But oil shale has yet to be exploited, while up to 150,000 barrels of oil a day are now coming into the Canadian crude oil supply system from the northern Alberta tar sands.

Why one, and not the other?

Because of differences in U.S. and Canadian policies affecting innovation in exploiting natural resources, says **Frederic A. L. Holloway,** Sc.D. '39, former vice president — science and technology of Exxon Corp.

There are crucial differences in four policy areas affecting innovation, Dr. Holloway told members of Industrial Research Institute late last spring:

☐ *Environmental regulations and permitting procedures.* Environmental requirements in the U.S. are both complex and un-

Northern Telecom Electronics. . . . **Earle W. DuBois,** S.M. '50, was recently elected vice president for corporate relations of Westinghouse. He was previously general manager of uranium resources for the company. . . . **Kurt E. Petersen,** Ph.D. '75, has an article published in the July issue of *I.B.M. Journal of Research and Development* entitled "Micromechanical Membrane Switches on Silicon." . . . **Peter J. Denning,** Ph.D. '68, has been appointed head of the computer sciences department at Purdue University. The department was founded in 1962, and is the oldest in the U.S. Dr. Denning joined the faculty in 1972.

Charles H. R. Campling, S.M. '48, is president of the Canadian Society of Electrical Engineering. . . . **Ralph Johnston,** S.M. '58, writes that he is managing a small analog design group at Data General. . . . A year ago, **Arthur Fox,** S.M. '72, started a new company called Octek, Inc. They make image analysis equipment and Mr. Fox is vice president of engineering. . . . The *Bell Laboratories Record* has three authors among our alumni: **Gerard P. Hayward,** S.M. '64, wrote on "Delivering business customer products"; **Neil F. Dinn,** S.M. '69 on "Facilitiating the use of digital radio"; and **R. Allen Bruce,** S.M. '61, on "No. 4 ESS: a continuing evolution."

Wilbur L. Pritchard, '52, reports that he is president of Satellite Systems Engineering, a consulting firm. . . . **William B. Macurdy,** Ph.D. '62, has been elected vice president-transmission systems of the research and development unit at Bell System. . . . MITRE announces that **Nelson E. Bolen,** E.E. '60, has been named head of the Information Distribution Systems Department. . . . **R. H. Fuller,** '54, is vice president — technology for Emerson Electric Co.

The Cal Poly Pomona's school of engineering gave their 1979 Distinguished Alumnus Award to **Robert W. Brodersen,** Ph.D. '72, professor at U.C., Berkeley. . . . **Peter J. Metz,** E.E. '67, has rejoined the staff of Arthur D. Little after serving as undersecretary of transportation for the Commonwealth of Massachusetts. He is particularly interested in the problems of railroads and other modes of transportation in a period of change. His client work will focus on modern systems analysis techniques. . . . **Ko Muroga,** S.M. '54, was just reassigned from Tokyo, Japan, to Irving, Tex., as executive vice president of N.E.C. American Corp. . . . **Jonathan J. Sirota** S.M. '64, has been elected a corporate vice president of Unitrode Corp., a manufacturer of electronic devices.

X
Chemical Engineering

Walter S. Scheib, S.M. '52, retired from the U.S. Department of Energy last winter, to join Mechanical Technology, Inc., in its Washington, D.C. office. . . . **James B. McNeely,** S.M. '57, has a new position as manager, Crystal Products Department of Laser Diode Laboratories. . . . **David K. Lam,** Sc.D. '74, writes, "I am president of my newly formed company, Lamtek Corp., which is located in California's North Santa Clara County (also known as Silicon Valley), doing consulting in plasma dry processing of semi-conductor devices, and marketing and sale of plasma processing equipment." . . . **Allyn J. Ziegenhagen,** S.M. '59, has been named research associate at Stauffer Chemical Co.'s de Guigne Technical Center in California.

XV
Management

Edward N. Dodson, S.M. '61, writes that he is chairman of the board of directors of the Metropolitan Transit District in Santa Barbara, Calif. and consultant to NATO in Bonn and Athens, as well as still the director of economic resources and planning operation of General Research Corp. . . . **Donald W. Male,** S.M. '58, has been

F. J. Corbato

certain, said Dr. Holloway, including the possibility of legal challenges which seem to go on endlessly. It's a little different in Canada: "environmental concerns are usually handled between government and industry in more of a spirit of cooperation than confrontation.

☐ *Taxation.* Dr. Holloway thinks tax laws are more favorable to innovation in Canada than in the U.S. — enough to represent a 2 per cent increase in return on investment. And that, he said, "could be the turning point in a decision to stop or go."

☐ *Pricing policies.* Only recently has shale oil used as refinery feed been qualified for the free-world, open-market price, said Dr. Holloway. Until 1978 it was governed by the same price regulations that affected domestic crude oil. Oil from the tar sands had price parity with the free-world open market — in contrast to domestic Canadian crude — from the start.

☐ *Leasing policies.* No one U.S. company can lease more than 5,120 acres of federal oil shale land — sufficient to support only one plant using modern technology. This effectively prevents any company from applying what it has learned on its first plant to a second which would presumably then be more efficient, and that reduces the incentive for investment "in a risky first plant," Dr. Holloway said. In Canada there have been no such "unrealistic limits."

Corbato Is Green Professor

Fernando J. Corbato, Ph.D. '56, formerly Associate Head of the Department of Electrical Engineering and Computer Science, has been named Cecil H. Green Professor of Computer Science and Engineering; it's a professorship especially designed to help members of the faculty move into new areas of research, and Professor Corbato will use it to study the rapidly-evolving technology of very-large-integrated-circuit design.

Professor Corbato was a charter member of the M.I.T. Computation Center in 1956, and he received wide recognition for his work on the M.I.T. Compatible Time-Sharing System demonstrated in 1961; this led in turn to the Multiplexed Information and Computing Service (MULTICS) in 1969.

A Career Development Chair in International Management from Mitsubishi

The Mitsubishi Companies of Japan will provide $400,000 for a career development chair in the Sloan School of Management. The idea is to reinforce the school's work in international management: the holder of the chair — it will rotate — will devote some of his or her research and teaching towards better understanding of Japanese culture, history, and institutions.

The concept is credited to the late General James B. Lampert, S.M. '39, when he was vice president for resource development; Peter P. Gill, associate dean of the school, helped to focus it into the area of international management.

The "Outside Director" as an Endangered Species

The American corporate system relies heavily on the sharing of problems and solutions which occurs in dark-paneled board rooms, where presidents of companies come together as directors of another company. But now there's a crisis in that board room, says **Fred Shinagel,** S.M. '55, in *Directorship:* the pressures on company presidents, and the growing responsibilities of boards of directors, are together giving "outside" directors more work than they can handle.

When push comes to shove — and it's coming — the "outside" directorship will yield to the primary corporate duties, says Mr. Shinagel; and so the board of directors as we know it may be an endangered species.

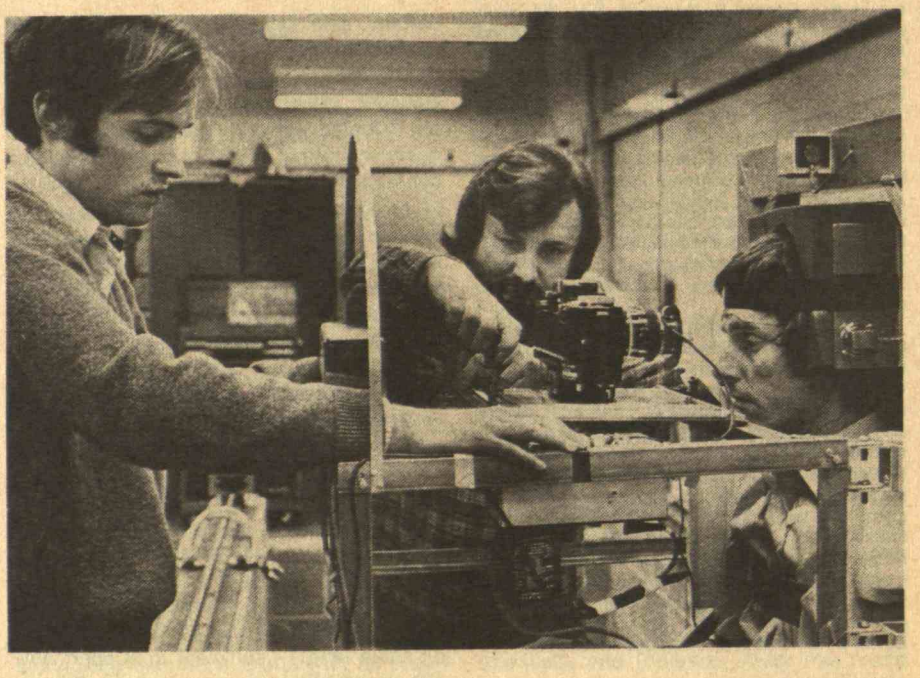
Every chief executive is aware of the proliferating responsibilities which roost on his desk. The same thing is happening to "outside" directors: there are more committees of the board on which he must serve, and their tasks are more demanding — stockholder relations, ethics, long-range planning, financial management, affirmative action . . . all sticky problems for the modern corporation.

They are also sticky problems for the "outside" director, for the stakes are high: " 'Due diligence' has become more than just a buzz word of corporate governance," writes Mr. Shinagel. "It now requires a serious and independent scrutiny by directors exercising in full the responsibilities of their positions. And its neglect involves the risk of serious personal liability."

Can the "outside" director system be saved? Mr. Shinagel thinks so: let corporations provide staff support for their "outside" directors, he argues, just as they do for their principal officers. The "outside" director would then have the help he needs — just as he does on his "inside" job.

Mr. Shinagel's suggestion also ends a curious perversity in the present system. With staff help "inside" but none "outside," the "outside" director may well find himself giving his "outside" job more attention than he gives his "inside" one.

The man in the harness (right) is Ulf Merbold, a German space scientist training for the Spacelab mission of the Space Shuttle, scheduled for 1981. He's taking a motion-sickness test designed by Professor Laurence R. Young, '57, Director of the Man-Vehicle Laboratory, while two members of the laboratory complete adjustments on the equipment. The purpose was to help Mr. Merbold prepare for the weightless environment of space —and to test Professor Young's test of his ability to cope. (Photo: Calvin Campbell)



elected to the board of trustees of the Unitarian Universalist Association for a four-year term. . . . **George Beard,** S.M. '73, reports that he has purchased controlling chares of Boston Investment Group where he will increase emphasis on the development of new products in energy and digital electronics fields, with potential consumer goods applications. . . . **Toby S. Mannheimer,** S.M. '77, is currently working for the Bendix Corp. in New Jersey and living in New York City.

Howard Mandelbaum, S.M. '65, has been promoted to senior vice president of William Douglas McAdams advertising agency in New York City. . . . **James H. Rial,** S.M. '47, writes, "General manager of operations for Unijox Converting Division — a subsidiary of International Utilities; president of International Association of Printing House Craftsmen. I'm married with three children. Son Jim is history professor of Allegheny College." . . . And from **Eric Herzog,** Ph.D. '73, "I have started my own management consulting firm, with projects in career and management development, productivity improvement, and planning. My first child was born in June." . . . **Bruce W. Bean,** S.M. '69, reports: "Mary and I have moved to Minneapolis, where I am working for First Bank System — a regional banking holding company with 91 affiliates in five states."

R. Gary Schweikhardt, S.M. '73, just left Boeing Computer Services to join Mathematical Sciences Northwest as vice president for administration and chief financial officer. . . . **Stanley C. Abraham,** S.M. '68, has had his first book published, "The Public Accounting Profession: Problems and Prospects" by D.C. Heath. . . . **Gary B. Hirsch,** S.M. '69, writes, "I continue to direct the health care consulting activities of Pugh-Roberts Associates, A Cambridge firm. My wife Linda and I live in Wayland, Mass., with our sons Adam, 6, and Daniel, 1½". . . . **Joseph V. Iemolo,** S.M. '62, is first vice president of the M.I.T. Club of Delaware Valley and executive committee man.

H. B. Christianson's, S.M. '53, current assignment is to prevent train accidents and highway-rail crossing accidents for Chessie Systems, the nation's leading carrier of coal. . . . **David R. Chittick,** S.M. '69, notes that he just completed building a new house, about a mile from his former one. . . . **Robert Cayleff Weiss,** S.M. '74, has been elected second vice president of Chase Manhattan Bank. He's serving as international marketing officer and product manager. . . . **Michael A. Leonard,** S.M. '71, writes, "We have recently moved. I am now vice president and group executive, automotive control systems group at Bendix Corp."

Robert H. Wilkie, S.M. '53, just retired from General Motors after 34 years; he'll now be living on Cape Cod. . . . **Howard Phelps,** S.M. '68, recently resigned after eight years as president of Boeing Aerosystems International to form a new company, Aerosystems Management and Engineering Co., which will be headquartered in London and offer services to Middle Eastern and African countries. . . . **K. A. Matheson,** S.M. '51, is vice president, employee relations of Armstrong Cork Industries, and has been with the company for 25 years now. . . . **Chas. W. Campbell,** S.M. '63, is general manager of Western Mining. . . . **Leslie Hruby,** S.M. '73, got a new job this year as product manager for Decsystem of Digital Equipment Corp.

"M.I.T. Aero & Astro," it says on that T-shirt being handed to H.R.H. Charles, the Prince of Wales. The occasion was Prince Charles' appearance as keynote speaker at an energy and aerospace conference in London last December; Professor Rene H. Miller, who is seated at the Prince's left, had just given the welcoming address, and David B. S. Smith, an M.I.T. graduate student who was reporting to the conference on his satellite power system studies, added his own American greetings. Also in the picture is M. L. Grainger (on Professor Miller's left), scientific attache to the American Embassy in London.

XVI

Aeronautics and Astronautics

Carl Alexoff, S.M. '56, has been appointed president of Systems Operations, a subsidiary of Mathematica. . . . **Dino A. Lorenzini,** Sc.D. '70, has been graduated from the Naval War College in Newport, Rhode Island. . . . **Lester L. Small,** S.M. '68, is employed as a project engineer for the Air Force Aero Propulsion Laboratory; he's also attending the University of Dayton in the Engineering Management Department. . . . **Larry M. Sweet,** Ph.D. '74, has been promoted to associate professor in the Department of Mechanical and Aerospace Engineering at Princeton University.

XVII

Political Science

News concerning careers Political Science alumni have chosen continues to be received for this column. Our alumni reflect a diversity of interests and career opportunities possible with Political Science training.

Academia: **Zakaria Bin Haji Ahmad,** Ph.D. '77, is lecturer and head of the Department of Political Science at the Universiti Kebangsaan (National University of) Malaysia. Dr. Ahmad is also vice president of the Malaysian Social Science Association and chief editor of *Akademia* (the University's Social Science journal). . . . **Davis Bobrow,** Ph.D, Professor of Government and Politics at the University of Maryland will be teaching in Tel-Aviv, Israel from October to June 1979-80. . . . **David Pyle,** S.M. '77, is a doctoral candidate in M.I.T.'s Political Science Department working on international nutrition policy planning. . . . **Heinrich Siegmann,** S.M. '78, is in Stuttgart, West Germany, writing his doctoral thesis. . . . **Mitchell Wallerstein,** Ph.D '78, is assistant professor of international relations at the College of the Holy Cross and lecturer of Political Science at M.I.T.

Foundations and Research Institutions: **Amaury De Souza,** Ph.D. '78, is a research investigator at the Institute for Social Science Research, University of Michigan, Ann Arbor, working on population policy and Brazilian elites.

Government: **Robert McMahon,** S.M. '75, is vice consul at the American Embassy in Quito, Ecuador. He spent two months this summer in Havana, Cuba, working on refugee problems and programs. . . . **Robin Reenstra,** S.M. '77, Ph.D '80 (exp.), is a consultant to the Rhode Island State Government, engaged in efforts to transmit University of Rhode Island faculty expertise to State Government agencies. . . . **Kenneth Smith,** S.M. '70, is a foreign service officer — project management specialist/advisor for the U.S. Agency for International Development, Department of State. . . . **Richard Speier,** Ph.D '68, is a foreign affairs officer with the U.S. Arms Control and Disarmament Agency working on nuclear non-proliferation, particularly with respect to the nuclear fuel cycle. . . . **Mitchell Tyson,** S.M. '78, is legislative assistant for Energy, Science, and Technology in the Office of U.S. Senator Paul

Filmed for the M.I.T. cable. Television cameras were on hand this spring when Robert Howard (right), staff photographer for the Boston Herald American, *talked about newspaper pictures in the class in Media and Public Policy conducted by Edwin Diamond, senior lecturer in the Department of Political Science. The* Herald American's *staff had just won the 1979 Pulitzer Prize for feature photography, and the class session was taped for later use on the cable. (Photo: Calvin Campbell)*

Tsongas, Washington, D.C.

Private Sector: **Stephen Adler,** Ph.D '75, is coordinating consultant, Technical Cooperation Service/OECD in Paris, France. . . . **Alexander Paulus,** S.M. '79, is a management consultant with McKinsey and Co., in Hamburg, West Germany, doing consulting for business and government as well as organizational studies in European companies. . . . **Janet Wynn,** S.M. '75, is chief, Check Processing Department, at the Federal Reserve Bank of New York.

Social Notes: **Davis Bobrow** writes that his wife Gail will also be teaching at the university in Tel-Aviv, Israel this year, and that their son, Sam, has mastered the art of walking. . . . **Robert McMahon** and his wife, Mary, just returned from a fascinating trip to Peru where they visited Machu Picchu and Cuzco.

Political Science Department News: Professor **Suzanne Berger** recently returned from a visit to China. Professor Berger was the only social scientist in a 10-member group invited by the Institute to tour major Chinese universities and research centers. The trip was organized around science and technology and culminated in a visit with Vice Premier Fang Yi. Included on Professor Berger's itinerary were Peking University, Tsinghua University also in Peking, Cheking University in Hangchow, Fudan and Chiao Tung Universities in Shanghai, and the Chinese Academy of Social Sciences.

Professor **Wayne Cornelius** will be leaving M.I.T. to accept a position at the University of California, San Diego. His wife, **Ann Craig,** Ph.D. '78, has also been appointed to the faculty as assistant professor. M.I.T. has appointed a new assistant professor in the Political Science Department to teach urban affairs. Dr. **Emma Jackson** is an alumnus of Florida State University '77, and joins M.I.T. from Miami University. **Donald Morrison,** Ph.D '80 (exp.) has been appointed an instructor in the Political Science Department to teach statistics courses connected with political analysis requirements.

The Compton Fellowship for Minorities and its stipend of $5,000 was won by graduate student **Marsha Coleman. . . . Clark Abt,** Ph.D '65, has offered an annual prize for the best essay in the field of public policy in the Department. This year the Abt Associates Annual Competition on Domestic Public Policy was won by first-year graduate student **Maureen King.** Maureen received $1,000 for her paper entitled "Balancing Trade Secret Protection Against Regulatory Disclosure in the Implementation of the Toxic Substances Control Act and the Occupational Safety and Health Act." . . . We extend our best wishes and congratulations to the award winners and faculty, departing and newly appointed.

Elly Terlingen still has copies of alumni addresses available and will be happy to distribute them upon request. Alumni will be interested in noting that the Institute has changed its policy towards non-resident dissertation doctoral candidates. Under certain conditions such students can register at substantially reduced tuition. Graduate students are also encouraged to get an S.M. prior to the Ph.D.

Postcripts: We plan to devote the next column and perhaps some future issues to publications authored by our alumni. Please be sure to send this information and any other news to me. As always, we enjoy hearing from you and learning about your progress, accomplishments and career activities. We also hope that we will have some announcements about alumni activities to publish soon. Stay in touch! — Dr. **Rhonda Crane,** Political Science Alumni Activities, M.I.T. Alumni Center of New York, 50 East 41 St., New York, N.Y. 10017.

Puzzle Corner

Allan J. Gottlieb

Mrs. White's Groceries vs. Mrs. Black's Cloth

Allan Gottlieb studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973); he is now Assistant Professor of Mathematics and Coordinator of Computer Mathematics at York College of the City University of New York. Send problems, solutions, and comments to him at the Department of Mathematics, York College, Jamaica, N.Y., 11451.

There seems to be some confusion concerning John Rule's challenge presented at the beginning of this department in June/July. We are seeking four digits which — when combined through the operations of addition, subtraction, multiplication, division, and/or exponentiation — yield all the integers from 1 to 100. Following Harry Hazard's suggestion, I am designating this problem as **PERM 3.** Mr. Hazard's preliminary results are presented in the "Better Late Than Never" section, below. For more details, see the description of the "yearly problem" in December/January, 1980.

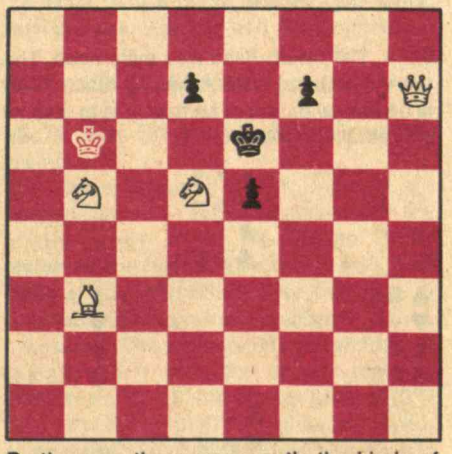
In December/January, nearly a year ago, we presented a problem from Frank Rubin. Unfortunately, we omitted an important phrase. So many readers enjoyed working on this flawed problem that we are reprinting it (correctly, I hope) in this issue.

Problems

NS17 (ne **1978 FEB 3**) We begin with a past problem that was *N*ever (completely) *S*olved, originally submitted by Sheldon Razin: Given an n-by-n checkerboard and n^2 checkers of n different colors, and given that there are n checkers of each color, is it possible to arrange all the n^2 checkers on the board so that no two checkers of the same color lie in the same row, column, or diagonal? (By diagonal is meant *all* the diagonals, not just the two main diagonals.)

When the problem appeared last year, several responses were received. An algorithm for placing the checkers was given for n divisible by neither 2 nor 3 (i.e., n = 1, 5, 7, 11, 13, . . .). Although this algorithm was not proved to generate a desired placement of the checkers, this is not hard to do. What remains to show is that no solution is possible for the remaining values of n (or else find such solutions).

NOV 1 Winthrop Leeds has a mate-in-two for us to try:



By the way, these are exactly the kinds of problems that current computer chess programs handle very proficiently. As this is written, I'm looking forward to attending the North American championships in October, and I'll be surprised if any of the contestants could not solve this in a few minutes.

NOV 2 Here is the Rubin problem mentioned above: The King wanted to find out who was the wisest among his three Grand Counselors. He blindfolded the three and then announced that he had eight Great Seals, four purple and four gold. He would place two upon the forehead of each Counselor, so that each Counselor could see the four seals on his neighbors but not his own two seals. The last two seals he would place in a locked chest. The first Counselor who determined the seals in the chest by correct reasoning would become Supreme Counselor; but if he guessed the answer, either rightly or wrongly, he would be beheaded. The King then put a purple seal and another on the head of Adak, a gold seal and another on the head of Baraz, and two more seals on the head of Cabul. After placing the last two seals in the chest, he removed the blindfolds and began questioning the three Counselors. "What seals are in the chest, Adak?" "I do not know." "What seals are in the chest, Baraz?" "I do not know." "What seals are in the chest, Cabul?" "I do not know." Disappointed, the King tried again: "What seals are in the chest, Adak?" "I do not know." "What seals are in the chest, Baraz?" And this time Baraz answered correctly, changed his name to Kissinger, and became Supreme Counselor. What seals are on each man's forehead?

NOV 3 Roy Sinclair has a spherical geometry problem for us: A spherical square ABCD is drawn on a sphere of radius R and center 0, with each arc AB, BC, CD, and DA subtending an angle X at 0 and each vertex angle of size Y. Find Y as a function of X and the area of the square.

NOV 4 Irving Hopkins submitted a spin-off from **1977 JAN 4.** The 1977 problem, from Ted Mita, was: A swimmer who swims at a constant rate of two miles per hour relative to the water wants to swim directly from point A to a point C, which is one mile downstream and on the other side of a river one mile wide and flowing one mile per hour. At what angle should he point himself, relative to the line AB which is perpendicular to the river? Mr. Hopkins' version is as follows:

1. Prove that the answer to **JAN 4** is (arcsin 0.75)/2, and find the time required and the distance swum (needed for comparison with 2. and 3., below).
2. The swimmer's sister and their uncle also swim at 2 miles per hour. The buoyant sister loves the water but hates exertion. What does she do?
3. The uncle, a self-made man, scorns the nephew's approach (too intellectual) and the niece's (too self-indulgent). He follows his life-long method of fixing his eye on the objective and steering straight for it. Find his path and how long he takes.
4. Let $V > 2$ be the speed of the river. At what angle θ should the nephew swim to cross the river and land as little as possible downstream from B? And how far down-

stream will he be?

NOV 5 Our final regular problem is from John Rule: Mrs. Black and Mrs. Brown bought cloth, each paying as many cents per yard as she bought yards. Mrs. Green and Mrs. White bought groceries. Mrs. Green spent one cent more than the excess of twice Mrs. Black's payment over seven-ninths of Mrs. Brown's. Mrs. White spent as much as the sum of two-thirds of Mrs. Brown's payment and one-half of Mrs. Green's. Mrs. Black's expenditure was equal to five-sixths of Mrs. Green's payment, plus one-third of Mrs. White's. The total expenditure was more than $1 and less than $10,000. How much money, in dollars and cents, did each woman spend?

Speed Department

NOV SD 1 I bet you didn't know that $-1 = 1$. Jukka Korpela sent the following "proof" to the *Sigsam Bulletin:*

$$-1 = i^2 = (i)(i) = \sqrt{-1}\,\sqrt{-1} = \sqrt{(-1)(-1)} = \sqrt{1} = 1.$$

What is wrong?

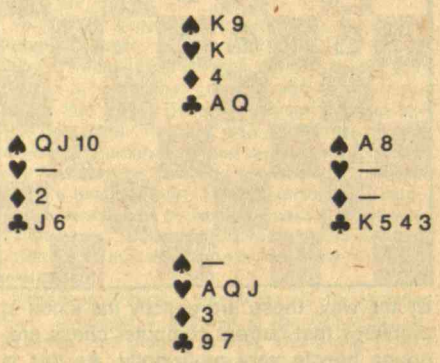
NOV SD 2 Another apparent contradiction — this one from Smith Turner: In two contiguous states, the per capita incomes are:

State A — $14,000
State B — $10,000

Jones, living in A, has his pay cut from $13,000 to $12,000 and, feeling that he can no longer afford to live in A, moves to B. Now taking a $13,000 income out of A obviously raises the average there, and putting one of $12,000 into B raises its average. Thus Jones has raised the per capita income in each of two states! But, taking A and B together, all that has happened is that income has dropped by $1,000 so the average of the whole area has dropped. What's wrong here?

Solutions

J/J 1 The South hand was misprinted. The correct problem is the following: South, who is on lead with hearts as trump, is to take all six remaining tricks:



Solutions will be given with those to the November problems. The error was noted by Michael Kotch, Winslow Hartford, Emmet Duffy, William Katz, and Harry Hazard.

J/J 2 A dog crossing a river swims directly towards his master at two miles per hour. The master is directly across the stream at the start. When the dog is two-thirds of the way across the stream his upstream velocity component equals the velocity of the river. The dog swims five minutes longer than if the water had been still. How wide is the river and what is the velocity of the water in it?

The following solution is from W. Woods: The river is one-half mile wide, and the velocity of the water is one mile per hour. The derivation: Let

L = width of river in miles;
v = dog's velocity = 2 miles an hour;
V = velocity of river;
y = downstream deviation from a straight line normal to the starting point; and
x = distance normal to river flow the dog is from his master's side of the river.

Then $y = 0$ when $x = 0$ or $x = L$; and $x = L$ when time $(t) = 0$.
The rate of travel in the x direction is

$$dx/dt = -vx/\sqrt{x^2 + y^2} \qquad (1)$$

The rate of travel in the y direction is

$$dy/dt = V - vy/\sqrt{x^2 + y^2} \qquad (2)$$

Dividing (2) by (1) to eliminate dt, and integrating yields

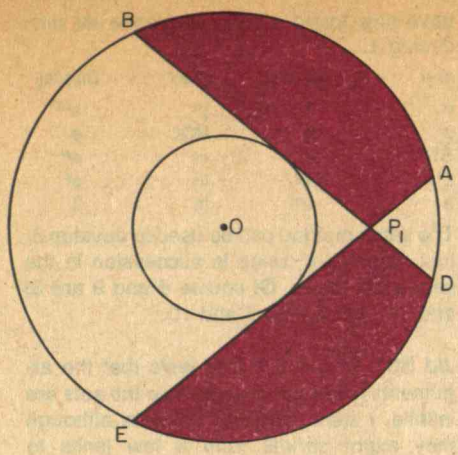
$$y + \sqrt{y^2 + x^2} = x(x/L)^{-V/v} \qquad (3)$$

When $x = L/3$, $dy/dt = 0$. Substituting these values in (2) and (3) yields $V/v = 0.5$.
Hence $V = 0.5 \cdot 2 = 1$ mile per hour.
Using (3) to define y, integrate (1) from $x = L$ to $x = 0$, obtaining $t = 2L/3$.
When $V = 0$, $t = L/v = L/2$. Hence $\Delta t = L/6 = 5/60$ hours; $L = 0.5$ mile.

Also solved by Irving Hopkins, Donald Savage, Conrad Benulis, Mary Lindenberg, and the proposer, Norman Wickstrand.

J/J 3 The inner of two concentric circles has a radius of one inch while the outer has a radius of two inches. A random chord is drawn within the outer circle by the following method: a point (P_1) is located a random distance (0 to 2 inches) at some random direction from the center. A second point (P_2) is determined by the same method. The chord is drawn through the two points. What is the probability that it will intersect the inner circle?

Several readers made the same mistake on this problem: they assumed that probability was proportional to area. That is, since the large circle has four times the area of the small, these readers felt that P_1 has a probability of .25 of being inside the small circle. In fact the probability is .5 since half the possible radii are less than 1 and the radius alone determines whether P_1 is inside the small circle.
Thus, half the time P_1 is inside the small circle, guaranteeing that the chord meets the small circle. For the other half of the time, the proposer, William Butler considers the diagram at the top of the next page.



In order for there to be no intersection P_2 must be in the shaded region. Mr. Butler notes that this probability is twice the probability that P_2 is in B_1A. This later probability is the difference of the probabilities that P_2 is in BDA and that P_2 is in AP_1D. The first of these two probabilities is independent of the location of P_1 whereas the second depends on the radius of P_1. Thus the probability of no intersection is

(1/2) (2) Prob (P_2 in BDA) — Prob (P_2 in AP_1D).

Now some careful arguments (using integral calculus) are needed to calculate the two remaining probabilities (a copy of Mr. Butler's argument may be obtained from the editor). The final result is that the probability of an intersection is 0.896. When a computer simulation was run for 10,000 trials the result was 0.895.

Responses also received from Frank Rubin, Thomas Schonhoff, Anne Symanovick, David Emmes, Mary Lindenberg, and J. Jones.

J/J 4 The six digits in an automobile odometer occasionally show mirror symmetry — i.e., they are in the form xyz-zyx. How often does this happen during the complete 100,000-mile sequence through the odometer? Is there a particular 1,000-mile trip during which it would occur more often than on any other?

Frank Rubin sent us the following solution which handles both kinds of odometers — those with and without tenths of miles: For every three-digit combination xyz there is a unique reversal zyx. So there will be exactly 1,000 such palindromes. The distance between consecutive palindromes is determined by the number of digits that change. If $z < 9$, then two digits will change and the distance will be 1,100 miles; if $z = 9$ and $y < 9$, four digits will change and the distance will be 110 miles; if $y = z = 9$ and $x < 9$, six digits will change and the distance will be 11 miles; and if $x = y = z = 9$, then six digits will change and the distance will be one mile. Thus there are many trips that will include exactly two palindromes — namely, any trip whose start is less than a number of the form xy99yx by no more than 1000 − 110 = 890 miles. No trip can have three palindromes, since the minimum distance is 1,101 miles, from 999999 to 001100. I am here assuming the odometer registers miles, as in a Volvo, rather than tenths. Otherwise 11 palindromes can occur, say starting somewhere before 19999.1 miles and ending somewhere after 20990.2 miles.

More details on the non-Volvo case come from John Prussing: The maximum number of mirror sequences occuring during a 1,000-mile trip is 11. As an example, the trip between odometer readings of 09998.0 and 10998.0 contains the 11 palindromes: 09999.0, 10000.1, 10110.1, 10220.1, 10330.1, 10440.1, 10550.1, 10660.1, 10770.1, 10880.1, and 10990.1.

Starting from 00000.0, the palindromes occur every 110 miles. This pattern is restarted every 1001 miles and every 10000.1 miles. The palindrome at 1001 miles is 11 miles after the previous palindrome 00990.0 miles. The palindrome at 10000.1 miles is only 1.1 miles after the previous one. The 1000-mile trip containing the most palindromes must contain one of the 1.1 mile increments.

Also solved by Bruce Drew, Winslow Hartford, Jerome Taylor, Frank Carbin, and Avi Ornstein.

J/J 5 What is the longest English word (no proper nouns or chemical compounds, please) in which no letter occurs more than once — that is, all the letters in the word are distinct?

As usual with these problems, the real question is how outlandish should be the permitted winner. Surely everyone will grant the 14-letter AMBIDEXTROUSLY, found by Harry Hazard and the proposer, Kenneth Wise. Mr. Hazard, who must browse through Webster's *New International* for fun, found the 15-letter DERMATOGLYPHICS listed there. Curiously, he notes that UNCOPYRIGHTABLE (15) is *not* listed whereas Frank Rubin submitted this word and its 16-letter plural. Finally Alan Stiehl claims that VODKATHUMBSCREWINGLY (20) describes the application of thumbscrews by a drunken torturer.

Entries in the sweepstakes also came from Winslow Hartford and Avi Ornstein.

Better Late Than Never

NS 14 Jerry Griggs has submitted the following:
The answer obtained by Eric Jamin is apparently correct — at least it agrees with the answer given in W. W. Rouse Ball's *Mathematical Recreations and Essays*. Ball gives a nice presentation for the case in which the dominoes have number 0, 1, . . . , n for $n = 4$. The ordinary domino problem is $n = 6$. For $n = 4$, the answer given is 126720. For $n = 8$, the answer given is (2^{35}) (3^{13}) (5^3) (711) (40787). An older reference, given by Ball, is for an algebraic approach to the problem in M. Reiss, *Annali di Matematica*, Milan, 1871, vol. 5, pp. 63-120.

PERM 3 Harry (Hap) Hazard has obtained partial results on the John Rule challenge

mentioned in the introduction. Mr. Hazard writes:

The possible four-digit combinations can be divided into three groups; those with repeated digits, those without repeated digits but using zeroes, and those with neither repeated digits nor zeroes, exemplified respectively by the dates 1979, 1980, and 1978. I have examined all 126 combinations of the third type (which I considered the most promising of the three), with the following tentative results.

(1) I found no combination meeting the problem requirements.

(2) The best combination was 1-3-8-9 (or 1983, as a date to look forward to), which lacks only one: 79.

(3) The next best was 2-3-4-7, which lacks two: 58 and 87.

(4) Two combinations lack three: 1-3-7-9 (52, 55, 71) and 2-3-7-9 (49-59-67).

(5) Seven combinations lack four: 1-4-7-9, 2-3-4-8, 2-3-4-9, 2-3-6-8, 2-3-8-9, 2-4-5-7, and 2-4-6-7.

(6) The combination 1-2-7-8 lacks five, but none of these is under 91, so this has the longest starting run I've found (1-90).

(7) Four combinations will make all number from 1 through 100 if it were permitted to use only two or three of the four digits. Thus 2-3-8-9 lacks 69 (9x8-3, discarding 2), 74, (9x8+2, discarding 3), 82 (discarding 3 and 9), and 100 (98+2, discarding 3). Similarly, 2-5-8-9 lacks six (28, 70, 77, 80, 90, and 100, all of which can be formed with two or three digits), 3-5-7-9 lacks nine (52, 68, 73, 76, 86, 90, 92, 93, 97), and 5-6-7-8 lacks eleven (23, 24, 38, 42, 47, 52, 62, 68, 75, 91, and 92).

(8) The worst combinations found were 1-7-8-9 (lacking 23), 2-4-6-8 (also lacking 23), and 4-5-8-9 (lacking twenty). 1978 was a real stinker!

Y1978 Claude Ducret has responded.

1979 FEB 2 Joseph Steranka has found an alternate method of solution.

FEB 4 There seem to be some problems with the published solutions. Stan Lukzic notes that, starting from 0, the sequence ARC COS TAN produces an error. David Kessel notes that using the HP-45 one can do better than the results shown for at least three numbers:

Two: Cos e^x x^2 ln
Ten: Cos (f) 10^x
Nine: start with 10 (f) GRD (f) →DMS

Finally, Frank Rubin writes, I thought there must be something wrong with Smith Turner's solution because there is no "E" key on my TI-SR50. (I had only been able to produce 1, 2, 4, and 8 when I had tried the problem myself.) I knew something was really wrong — not just a typo — when I saw that he had obtained 7 by squaring the sequence for 3. Even I know $3^2 \neq 7$. So I tried his sequence for producing 3, using every possible key in turn for the missing "E." Nothing worked. I got either an error or π^8. I have now found a valid sequence for producing 3:

Key	Display	Key	Display
e	1	y^x	e^{e^3}
e	e	RCL	e
STO	e	=	e^{e^3}
x^2	e^2	ln	e^3
e	e^{e^3}	ln	3

The same method can be used to develop 5, just pressing x^2 twice in succession in the sequence above. Of course 6 and 9 are 3! and 3^2. This leaves 7 and 10.

J/J SD1 Waltvant Buser feels that the arguments given don't work since the sets are infinite. I stand by those answers although they might benefit from a few limits to infinity. But there is no time for infinite arguments in a speed problem.

Proposer's Solutions to Speed Problems

Both solutions this month are courtesy of the editor:

SD1 $\sqrt{a}\sqrt{b} = \sqrt{ab}$ is true when you restrict a and b to be positive reals. In general the square root is multiple-valued and more care is needed.

SD2 The average of the combined region is *not* the average of the two individual averages. Instead, it is the weighted average of these two averages. When Jones moves he increases the weight of the lower average and decreases the weight of the higher.

services, for example. These include private philanthropic agencies and foundations, the foreign assistance agencies of most of the donor nations, and regional development organizations. Many of the largest donors are awaiting more information on costs, performance, and reliability of renewable energy systems before making major commitments of funds and personnel. The World Bank is the most prominent example. Its leaders and analysts have acknowledged the problem of rural energy availability, but have not yet embraced small-scale renewable energy systems as a major solution, much less *the* solution.

It is difficult to estimate the total size of current foreign assistance loans and grants for renewable energy. This is partially due to a lack of coordination and information-sharing on assistance lending, even within individual governments and agencies, and partly to a lack of consensus on what actually constitutes a renewable energy system. A study recently completed by the Solar Energy Research Institute located approximately 300 such projects collectively funded at more than $225 million by 30 public and private donor agencies. The current yearly expenditure on these projects is difficult to compute, since most of these 300 projects extend over three-to five-year periods. I would project that the annual bilateral grants and lending for renewable energy projects by the major O.E.C.D. donor countries alone (i.e., by the "Western" industrialized nations) will reach $200 million within five years. This figure does not include current or future commitments by the World Bank or the regional development banks, nor does it include the current substantial programs of the U.N. specialized agencies, private foundations, and relief organizations.

Two hundred million dollars is a substantial annual expenditure, particularly on a problem that was not even considered for support by most assistance agencies four years ago. However, it is important to remember that this is an extremely small fraction of the more than $20 billion in aid provided by the major bilateral donors in 1979. In addition, the World Bank system is presently providing grants and loans for over $10 billion per year, with one billion of the 1978-1979 funds earmarked for energy-

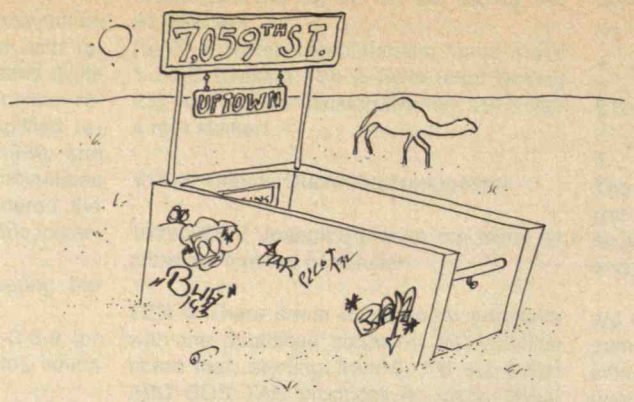
Traditional Fuels and Limits to Growth

There have been four major consequences of the increase in use of traditional fuels in the last decade. The first is that the balance between consumption for fuel and regeneration of forests and soil has been destroyed as use has risen. The result has been deforestation, particularly in the areas around major metropolitan sites. Each year the tree line has receded further from cities, as foragers who gathered only fallen branches have been replaced by professional wood-cutters who fell whole trees and clear sections of the forest without replanting.

Second, the loss of ground cover due to deforestation and to accelerated gathering has led to erosion of topsoil and to the pollution of groundwater sources. This has been particularly severe in mountainous terrain, such as in Nepal, and in areas with thin topsoil, such as the arid plains of sub-Sahara Africa. This type of erosion, combined with a long drought, was partially responsible for the rapid desertification experienced in the Sahel regions of Africa in the late 1960s and the early 1970s. It has also contributed to the loss of large sections of Himalayan forest cover in Nepal and neighboring states.

Third, available resources have been diverted from other valuable uses to combustion as fuel. This is especially serious for dung and crop residues. When they are used as cooking fuels, they are not returned to the soil as fertilizer. The result has been a progressive degradation of the soil quality, and a decrease in crop production. The impact of the loss of nutrients should not be underestimated. One researcher has estimated that the annual manure output of the cattle of India was between 120 and 310 million tons in 1971, and that 48 to 97 million tons of this total was being consumed as fuel. Even if rising population and scarcity of other fuels has only led to a 25 per cent increase in the burning of dung for fuel since 1971, this means an additional 12 to 24 million tons of dung not returned to the soil.

Finally, the growing scarcity of non-commercial fuels has meant that more time must be taken away from other pursuits in order to forage for firewood. In many rural societies, this additional burden has fallen most heavily on the traditional gatherers of food — the women and children. The increased time spent gathering firewood, dung, or agricultural residues for cooking is not only onerous, but also imposes constraints on agricultural production. In the Sudanese town of Bara, for example, the time to gather firewood has risen dramatically in ten years — from about twenty minutes to one to two hours — and its price has more than tripled. — *J.A.*



related projects — primarily large-scale hydroelectric power generation, coal development, and oil and gas exploration. A decision by the World Bank and the regional development banks to make renewable energy a major priority could trigger a multi-billion dollar solar energy development program.

Demonstration and Field Testing

Foreign assistance agencies have thus far confined most of their activities in renewable energy to the funding of demonstration projects. Such demonstrations provide a means for gathering performance data and cost estimates under actual field conditions. If carefully monitored and instrumented, demonstration projects can show how individual pieces of hardware must be modified to meet local environmental conditions. On a more practical level, demonstration projects can be quickly planned and executed. This is important for agency officials under political pressure to "do something" in solar energy. These projects can be inserted into existing development programs that are designed for other purposes. They are highly visible and not terribly expensive. Since a demonstration project is experimental, it doesn't require any major multi-year commitment by the agency to develop and promote solar energy.

A number of organizations took an early lead in the creation of renewable energy demonstration projects: the U.N. Development Programme (U.N.D.P.), the U.N. Environmental Programme (U.N.E.P.), the Organization of American States, and the foreign assistance agencies of France, the Netherlands, Sweden, Canada, and the United States. In the last two years, they have been joined by new institutional actors such as the government of West Germany, the Inter-American Development Bank, the aL Dir'iyyah Institute, and the Rockefeller Foundation.

Some of the current projects of these donors are continuations of long-standing assistance efforts. Since 1968, the French government has been providing the government of Niger with photovoltaic arrays to power special French solid-state DC television sets (designed for remote education programs and for government extension services). The Dutch government has been providing assistance for a number of years to Indonesian villagers to develop and install simple low-cost technologies such as crop dryers, solar hot water heaters, biogas digesters, and hydraulic water ram pumps.

Other programs are new directions within the traditional mandates of specialized agencies. For example, the U.N. Food and Agricultural Organization (F.A.O.), the U.N.D.P., and a number of bilateral donors have long been active in the funding of Third World forestry management and forestry crop improvement programs. Such an effort has been underway in Upper Volta since 1975, and has resulted in the establishment of more than 100 self-sustaining village woodlots, which use fast-growing tree species for maximum yield.

Demonstration projects can be divided, somewhat arbitrarily, into two types: technology "implant" programs and technology "transplant" programs. In a technology implant program, a donor nation or agency provides experimental or commercially available solar energy systems developed outside the Third World. In such cases, the local villagers and host government have little or no role in designing the system or in specifying its operating characteristics. It arrives as a pre-assembled unit or is shipped as modules and assembled on-site. This is by far the dominant pattern in renewable energy demonstration programs today.

One reason for using existing foreign hardware is purely pragmatic, based on the limited time and resources available to a project director. He or she faces the choice of using either an imported wind, solar, or small-scale hydroelectric system, or else a conventional fossil-fuel-fired energy system (usually a small diesel generator). The purpose of the project is not to develop a solar energy system — a costly and time-consuming process — but to use energy of some kind to meet basic rural needs. Another reason for technology implant is that the donor nation may hope to export its renewable energy systems to Third World countries. The humanitarian motives of helping the rural poor are mixed with the desire to create new markets. This is particularly true for

There have been some past spectacular failures to persuade rural people to adopt foreign technologies, even when provided free of charge.

expensive technologies such as photovoltaic (PV) cells.

The foreign assistance agencies of the major industrial countries — France and Germany, for example — have been active sponsors of technology implant projects. Other donor nations, such as the United States and Canada, initially sponsored such projects but have increasingly included solar technology experiments as small components of larger programs aimed at a non-energy development objective (integrated rural development, institution-building, etc.). The United States has installed a large PV array in Upper Volta, has jointly sponsored a solar thermal pumping system with France in Senegal, and is installing four small PV-powered pumps in Mali. In addition to the bilateral programs, a number of international and multilateral organizations are currently funding technology implant programs. The U.N.E.P. is setting up several rural energy centers using a mixture of imported technologies. The U.N.D.P. is sponsoring four projects in the next three years to demonstrate small-scale solar irrigation systems in India, the Sudan, Upper Volta, and the Philippines. Preliminary plans call for the installation of one solar thermal system and several small-scale PV systems at each of the sites.

In technology *transplant* programs, a renewable energy system developed inside the host Third World country — or in a developing nation with similar climate and energy needs — is installed at a test site by an outside donor agency. Such projects are often a part of the institutional support for a local university or energy center, and may be the last step of testing before local manufacturing facilities are built. Technology transplant projects are particularly important in the simplest and lowest-cost technologies, such as cooking stoves and crop dryers, where a wide variety of working designs already exist and where the need is for adaptation to local materials, customs, and environmental conditions. Rare until recently, these projects are now active in a number of countries. Since 1976, the government of Kenya and the United Nations International Children's Emergency Fund have operated a number of low-cost renewable technologies at a demonstration village outside Nairobi. The World Bank will be promoting the use of a number of existing efficient wood-burning stove designs in Mali and Burundi as part of larger wood energy usage surveys. The Inter-American Development Bank has provided $650,000 to the Central American Institute for Industrial Research to develop four small-scale technologies for rural applications, including solar crop dryers and methane digesters.

"Implanted" versus "transplanted" technologies, of course, provide a useful but artificial distinction. Imported technologies are not necessarily inappropriate for rural energy needs and conditions; they may be the best and most logical choice. Conversely, local researchers may simply duplicate foreign designs, without giving consideration to local climate, materials availability, and maintenance requirements.

Generally speaking, new technologies must undergo adaptation in order to be compatible with local cultural practices, local needs for technology, and the structure of the greater society. The development community has become aware of these necessities, primarily through some past spectacular failures to persuade rural people to adopt foreign technologies (such as birth control pills and solar cookers) even when the devices were provided free of charge. In the last five years, therefore, agencies have begun to provide funds to Third World governmental agencies, universities, and national laboratories to develop and modify solar technologies and to manage for themselves the installation and operation of demonstration projects.

Commercialization

Once existing technology has been successfully modified to use locally available materials, to ensure durability under local climatic conditions, and to reflect local consumption patterns and cultural constraints, it is ready for larger-scale production. Several such programs have been started. The World Bank is providing $165,000 for the development of renewable energy technologies appropriate to the harsh climate of Bolivia's mountain highlands. The Swiss government is helping to finance the develop-

Foreign assistance can provide designs and models, but each village must itself select, shape, and use them.

ment and manufacture of small-scale hydroelectric generators, hydraulic rams, and solar collectors in Katmandu, Nepal. In another effort, the Colombian government, the U.N.D.P. and the Dutch government have committed $800,000 to the design and construction of a factory to reproduce six low-cost technologies at the "Las Gaviotas" rural development center in Colombia. Included among these six, all created in Colombia by the staff of Las Gaviotas and by consultants from the University de los Andes, are a solar water heater, a small-scale hydroelectric system, and a windmill for pumping water.

The production of commercial hardware for renewable energy systems will naturally help to increase the rate of diffusion of these technologies. What role traditional foreign assistance agencies will play here is less certain, particularly for the major industrial nations. There is an inherent contradiction between the promotion of the export of technologies and the granting of funds to build those same technologies in potential markets. This problem is further compounded by the belief in some quarters that industrialization — aside from the creation of infrastructure such as roads, communications networks, and centralized power systems — should be carried out by the private sector and not by assistance funds.

Project Selection and Design

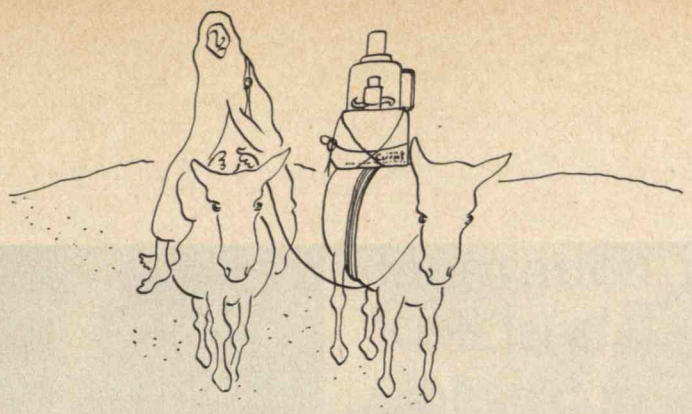
Because the experience with donor funding of renewable energy sources has been so modest, conclusions cannot yet be made about the impact of these institutions on the distribution of renewable systems (or, for that matter, about the impact of the new technologies upon the procedures of the major multilateral and bilateral agencies). Adjustments *are* taking place, however, due to political pressures to promote solar energy and to the increasing importance being placed on the non-economic impacts of a development project. A new emphasis is being placed on serving certain groups previously ignored — the poorest 40 per cent of the population and especially women, children, and the rural landless. Prospective World Bank projects are now scanned for environmental considerations and their impacts on population growth. Other organizations have similarly broadened their criteria for selecting among projects.

Price and market demand are not major factors in the selection of technologies by foreign assistance programs. What is important are the development objectives and internal processes of the donor institutions. These processes, in conjunction with those of the host government, will determine which of a large number of renewable energy systems will be selected, modified, and installed. It is crucial, therefore, that the donor institutions structure their project-and-technology selection processes to incorporate those factors that will ensure acceptance. Otherwise, technologies will be transferred (since they are free in most cases to the recipient), but will not be adapted to local conditions nor used by village consumers.

Selecting appropriate and locally acceptable technologies is a difficult process in the absence of market forces, even with perfect information on the factors that contribute to project success. Such information does not now exist. There are four criteria for project selection, however, which can help to provide needed information even while experimental systems are being introduced:

☐ *Definition of development objectives*. The selection of technologies for development projects is made virtually impossible without a clear description of the objectives of the project. A hierarchy of goals must be developed prior to project selection, and used to evaluate the success of the energy system, as opposed to simply evaluating the technical performance of the system without reference to what end-use needs it is supposed to satisfy.

☐ *Information collection and exchange*. Because renewable energy systems are so site-specific, each proposed project should allow for the collection of data on local energy-use patterns and indigenous energy resources. Once systems have been selected, adapted to local conditions, and installed, there is a need to closely monitor the performance of the equipment and to assess its compatibility with the local environment and local customs. Most importantly, all of this information should be widely shared among Third World planners and donor or-



ganizations, thus enabling successful technology choices and innovative system adaptations to be rapidly disseminated.

☐ *Quasi-experimental designs*. There is a strong need for development projects that are deliberately designed to provide information about the comparative performance of systems or to isolate external factors that influence project success. Different renewable energy systems can be installed in parallel in the same or neighboring locations and used to perform the same work. These systems would be exposed to the same external environmental and institutional influences. The output of the systems, their maintenance needs, their durability, and compatibility with local conditions could then be measured and directly compared. Alternatively, identical systems can be installed in series in a number of settings that vary from one another in a controlled fashion. For example, the amount of local participation in planning the project, the manner of distributing the system's output, and the manner of fabricating and maintaining the system could be three variables, which if linked in different combinations could determine which is more crucial to the successful adoption of the energy system.

☐ *Learning from prior field experience*. To make renewable energy systems work, foreign assistance institutions must pay heed to the lessons learned from previous programs of foreign aid. Technologies can be implanted without modification only if they meet actual needs, fit into local culture patterns, and are perceived as valuable by local users. In most cases, a significant period of learning and adaptation (by both the recipient and donating communities) is required, particularly when multiple technologies are being introduced to meet the same needs.

Selecting among the technologies ultimately rests with the villagers. The back lots of communities all over the Third World are littered with the rusted remains of machines which were selected by well-meaning development experts as being the "best" for the people. It must never be forgotten that solar energy systems are tools. Foreign assistance can provide an array of designs and models, but each village must itself select, shape, and use them.

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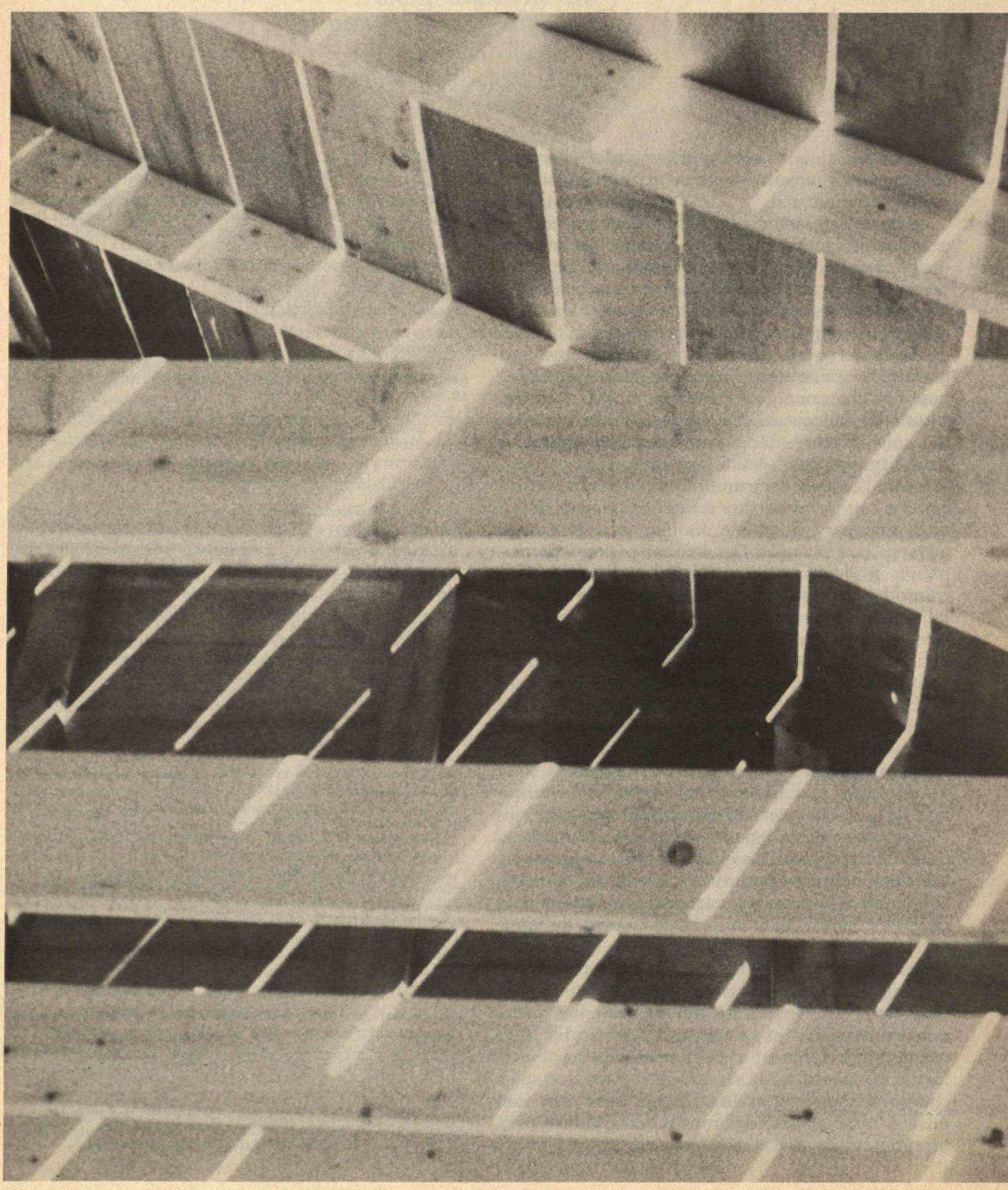

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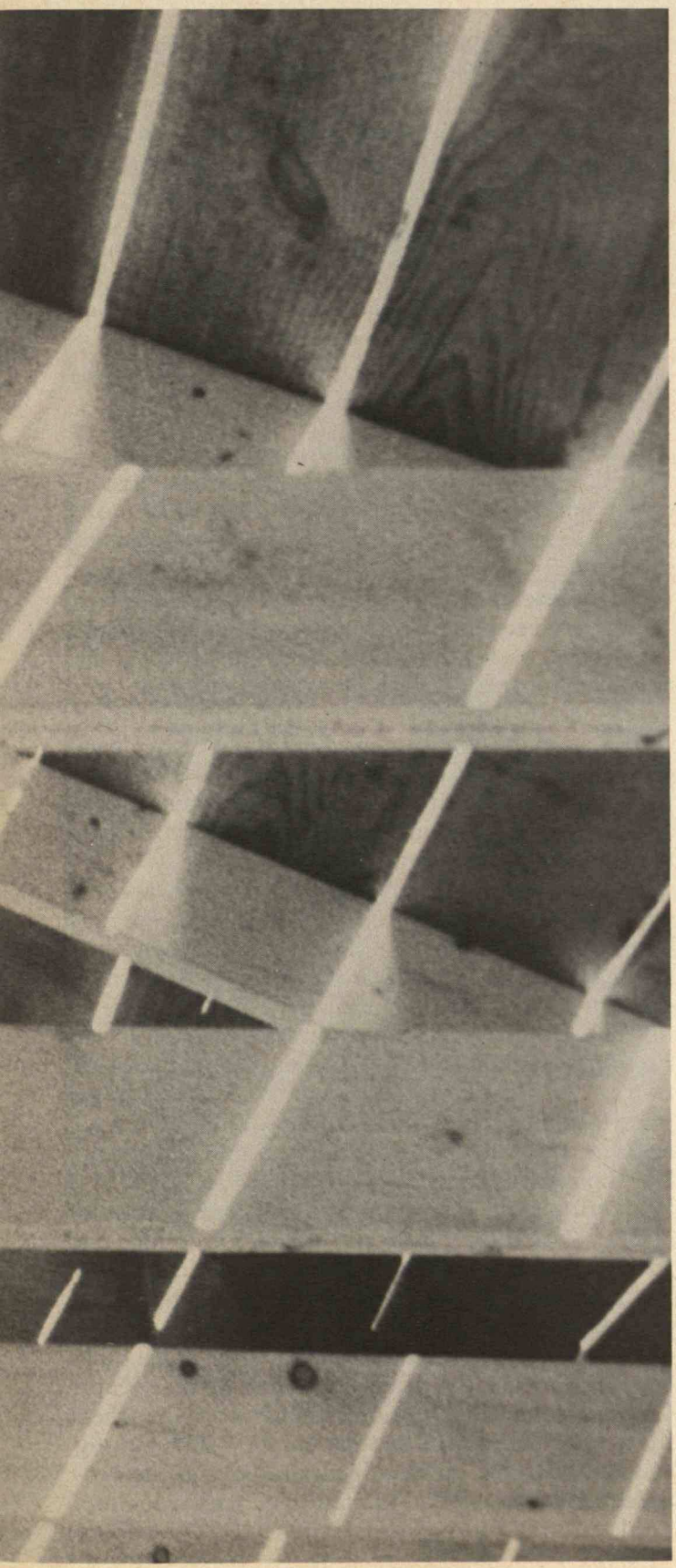


Innovation in Residential Construction

by Francis T. Ventre

"The industry capitalism forgot" is not really so obsolete after all. It only wants to look that way.

The construction industry, and especially housebuilding, is consistently stigmatized as "backward," sometimes called an enterprise that is not yet an industry. Seeking vivid metaphors, even sympathetic critics characterize the industry as "suicidal," a "headless monster," an "army of pygmies," and, according to *Fortune*, "the industry capitalism forgot."

This popular view inevitably follows from superficial observation of construction projects (such as those by "sidewalk superintendents"), from the appearance of the finished product (particularly single-family residences), and from the fact that enormous changes in technology of the past two decades are deliberately hidden from the final consumer. The industry has learned by hard experience that housing which too audaciously flaunts its advanced techniques encounters serious marketing problems, so traditional are consumers' preferences when it comes to their own housing. Indeed, one survey of 1,000 homebuilders reported that the threat of adverse consumer reaction is the primary inhibitor to innovation by builders; many housing producers do their best to shield from view changes in technology that have already been absorbed into their production methods.

This may explain why casual observers see so little evidence of advanced systems in residential construction, but it does not tell us why economists and students of industrial productivity are so unimpressed with progress in the building industry.

The image among economists of housebuilding as a "technologically stagnant" industry can be traced to a number of post-World-War-II economic studies that calculated construction efficiency and productivity by the same measures used for more conventional industries. These standard measures are, for reasons developed below, wholly out of place, simply inappropriate to construction activity. In some cases, these reports reached their conclusions about technology stagnation because they used bad data, repeating industrial statistics from as far back as 1890 and in some cases extending forward only to 1934. By the middle 1950s a few technical studies and one nonspecialist book had appeared to offset some of the earlier bias, but the mischief had already been done. The fact is that most analysts since 1950 have closed their eyes to a veritable "technological explosion" reverberating throughout the housebuilding industry.

This article summarizes some of the characteristics of the construction industry which have misled analysts; it traces the progress of 14 significant housing innovations to show that their adoption — with two notable exceptions — has been at least as rapid as the adoption of equally significant innovations in other industries; and it analyzes these two exceptions to show the nature of the constraints to diffusion in the housing industry and how those constraints might be reduced in the future.

Adapting to Diversity and Discontinuity

One of the sources of the erroneous image of the construction industry's languor is the notion, persistent even among technologists, that there is some minimal "scale" or threshold level of impact which must be achieved before a new development is properly designated "innovation" or "technological progress." Many units of the construction industry are small by this kind of measure, and the conventional wisdom is that to improve their efficiency they must increase their size.

A related criticism is that of "undercapitalization." Because of seasonal and annual variation in levels of activity, construction firms invariably show lower ratios of fixed capital to total assets than do manufacturing industries; and housebuilding is the most volatile sector in the construction industry: peak-to-trough amplitudes as great as 30 and 40 per cent occurred at least four times in this sector between 1950 and 1972. Contractors have learned the foolishness of owning and maintaining expensive fixed equipment with this enormous fluctuation of activity. Indeed, their management strategies place more emphasis on maintaining financial capital and a well-paid, highly skilled, enormously mobile, flexible work force. Smallness of size, primary reliance on manual skills, and a high rate of entry-exit may be viewed as shortcomings and signals of dysfunction among manufacturing entities, but these qualities are the adaptive construction industry's response to strong social and economic forces over which the industry has no control.

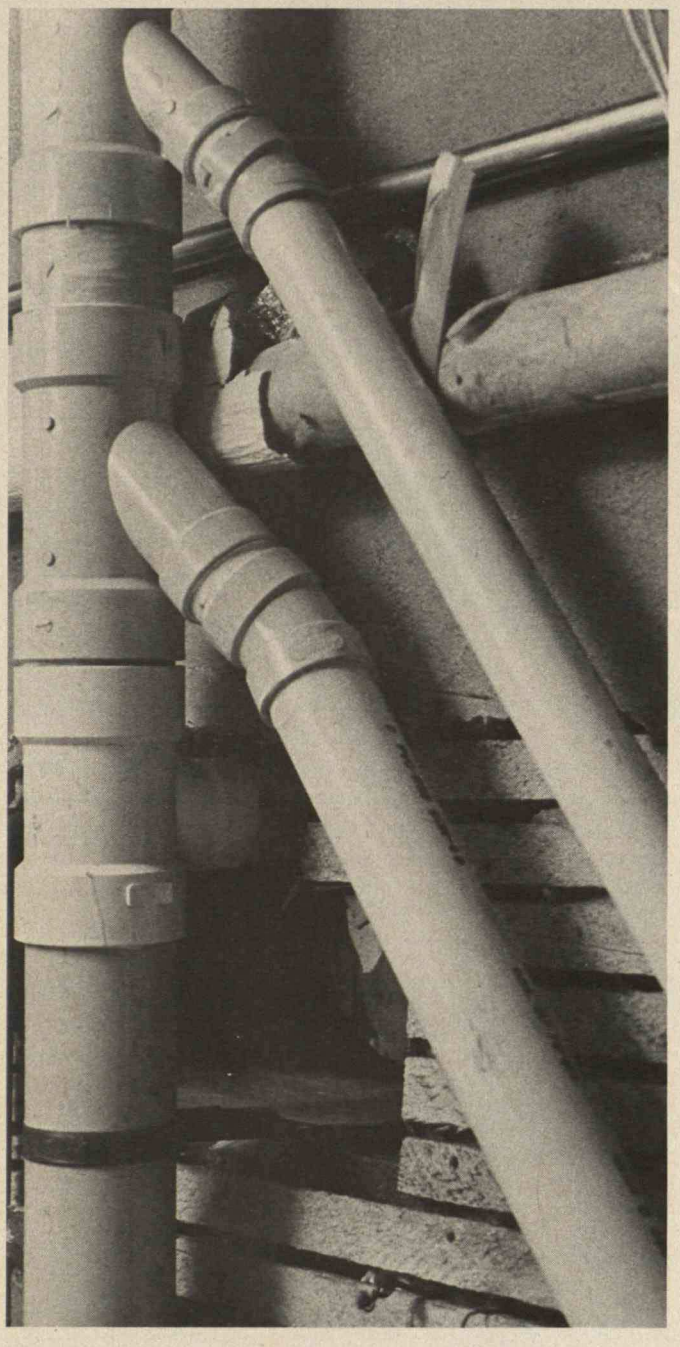
Flexibility and Responsiveness

The construction industry is diverse, dispersed, detached, and discontinuous — all characteristics which are viewed with dismay by analysts of more stable, highly capitalized, conventionally deployed industries.

☐ *It is diverse*: residential construction involves about 75 specialties organized by 17 craft unions. The range of specialties is sweeping: besides the well-known ones such as plumbing, electrical, and sheet metal work, there are such highly specialized trades as underground wire contractors, pipe insulation contractors, and others. Just over 70 per cent of the 800,000 construction establishments in the U.S. are subcontracting units highly specialized in just one area of building practice.

☐ *It is broadly dispersed*. Whereas other durable-goods industries have become identified with specific cities or urban regions — an economic geographer associates semiconductors with the San Francisco peninsula and Tabasco with Avery Island — there is no such geographical concentration in the construction industry. It is instead distributed across the nation as the population is distributed, the better to serve local need; fewer than 10 per cent of construction firms work beyond the borders of their states. And housebuilding is even more localized.

☐ *Construction enterprises are detached in several senses*: work moves from site to site, job to job; the particular subcontractual arrangements among the specialty firms on any single job are rarely repeated, making systems-oriented management difficult; this is less true of residential construction for home builders tend to use the same team over several years. Commercial and institutional builders are detached from their sources of supply, so they shift among vendors of highly differentiated products as their requirements change due to consumer taste, architectural fashions and cost.



Plastic pipe: ". . . even the most vociferous coalition of unions and building materials producers of recent years failed to stem or even to delay the diffusion of an innovation to which it was most strenuously opposed."

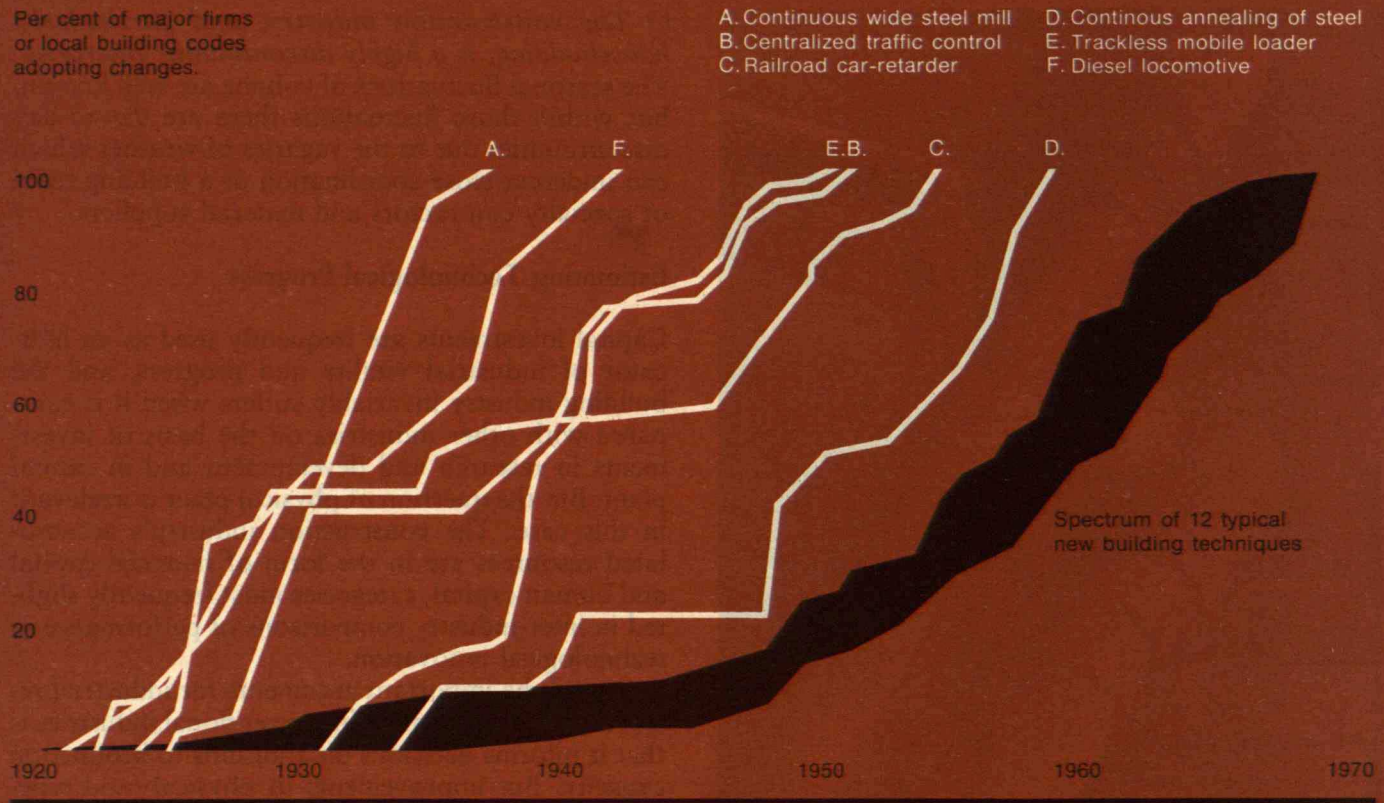
☐ *The construction industry, and particularly housebuilding, is a highly discontinuous enterprise.* The seasonal fluctuations of volume are well known, but within those fluctuations there are day-to-day discontinuities due to the vagaries of weather which can undercut close coordination of a building team of specialty contractors and material suppliers.

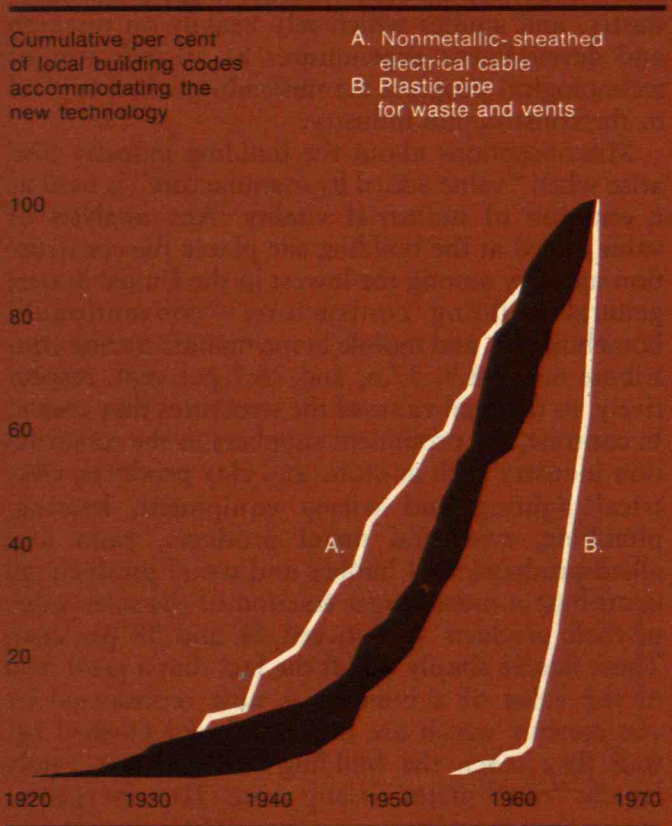
Estimating Technological Progress

Capital investments are frequently used as an indicator of industrial vitality and progress, and the building industry invariably suffers when it is compared with other industries on the basis of investments in research and development and in capital plant. But the question of physical plant is irrelevant in this case. The construction industry's accumulated resources are in the form of financial capital and human capital, categories most frequently slighted in inter-industry comparisons of performance in technological innovation.

One of the important arguments for industrial research and development in conventional industries is that it informs decisions on additions to production capacity. But improvements to physical (and especially, fixed) capital are not suited to the building industry, and studies which rely heavily on research and development expenditures as an indicator of technological progress are misleading when applied to the construction industry.

Misconceptions about the building industry also arise when "value added by manufacture" is used as a criterion of industrial vitality. Any analysis of value added at the building site places the construction industry among the lowest in the United States; general building contractors, "conventional" homebuilders, and mobile home manufacturing contribute only 28.9, 37.6, and 24.7 per cent, respectively, to the final value of the structures they create. In contrast, the prominent suppliers to the construction industry such as stone and clay products, electrical lighting and wiring equipment, heating, plumbing, structural metal products, paint and allied products, and lumber and wood products all contribute a much larger fraction of the sales value of their products — between 42 and 58 per cent. These figures simply reflect the fact that a great deal of the value of a building is now represented by components which are assembled and finished before they reach the building site; builders rarely handle "raw" materials any more. To a far greater extent than most laymen realize, all homebuilders —





Above:
What role for labor in resisting or embracing new building technology? Almost none at all, says the author, surveying his data on four out of the 14 innovative construction advances. Officials of the United Association of Plumbers and Pipefitters were more exercised over the introduction of plastic pipe for drain, waste, and vent lines than of preassembled bathroom plumbing units. Similarly, nonmetallic-sheathed electrical cable was of more concern to electrical union officials than preassembled electrical harnesses. But both plastic pipe and nonmetallic cable won more rapid acceptance in building codes. The author explains that in both cases unions were opposed to innovations which portended a change in the underlying social technology of marketing, distribution, and transportation.

Left:
Exceptions to the usual history of building technology diffusion. Of the 14 innovations studied by the author, two had patterns of acceptance very different from the rest: nonmetallic-sheathed cable found early and continuing adoption throughout the 1940s, and plastic pipe for drain, waste, and vent lines was embraced almost immediately in the 1960s. From these two cases the author draws suggestions for assuring more rapid dissemination of new building technology in the future.

not just the "industrialized" ones — are essentially in the business of materials-handling and installation rather than fabrication.

Another frequently alleged shortcoming of the building industry is its reliance on external resources for innovations that have later found widespread acceptance within the industry. Professor Donald A. Schon of M.I.T. calls this maneuver "innovation by invasion": a mature, stable, technologically retarded industry is invaded by technologically advanced, developing, expansive industries. The housebuilding industry seems to be an obvious example — the complaisant host to high-technology invaders, which implies technological morbidity on the part of the receiving industry. But this implication is unwarranted. It is true that most of the research and development dollars and new product development effort in the construction industry is made by the building materials sector. But this fact does not imply technological backwardness on the part of the receiving sector; in this case, negligible investment in research and development is an essential strategy for coping with the industry's volatile environment.

The fact that the building industry does not have an integrated research, development, testing, and evaluation tradition does present some serious hazards. Diffusion of new technology is slowed; the industry needs time to gain experience with the properties and uses of the new materials before a substantial commitment to them can be responsibly made. For a supplier, marketing a new building materials product means dealing with enormous volatility of demand and a fractionated market; no single customer is likely to account for more than a very small share of total production. This assures large problems for sales, inventory, and distribution.

An Empirical Measurement of Technological Change

Studies of the diffusion of innovations suggest that a society or industry "learns" to use a technology in much the same way that an individual learns and uses a new skill: slowly at first, then with increasing efficiency and facility until a plateau is achieved and performance levels off. The early users of an innovation appear in the left-hand portion of the curve, where it is almost flat. As these early users communicate the innovation to their peers, who then take up the practice, the pool of potential communicators increases and the rate of diffusion accelerates. Eventually, most potential users are made aware of the innovation and saturation is achieved, the diffusion process having run its course.

An industry's receptivity to innovation is sometimes inferred from the amount of time required for this process. Even for innovations which represent significant savings to a typical American industry, diffusion time may be as long as 30 years.

How does the process of diffusion operate in the construction industry? To answer that question, the author has analyzed the diffusion of 14 innovative construction advances which together comprise an index of technological currency in the industry. Each was an incremental advance in the state of the building art, the very kind of change — small in scale and often inexpensive — that historians of technology know to be the stuff of industrial progress. The 14 advances affect all of the major building trades engaged in residential construction. Any of the 14 could be readily applied and put to use by even the most modest-sized, least-enterprising construction entrepreneur; both general and specialty contractors are involved, as are the retail and wholesale merchants that serve the construction industry. The 14 items represent a variety of enforcement tasks for local building departments and all had been adopted by at least one of the cognizant model codes.

The 14 innovations were followed for the years between 1920 and 1970. For the purposes of the study, an innovation was considered "adopted" when local codes were modified to permit its use by local builders. The innovations were divided into three categories — those that affect materials of construction, those that affect building methods, and those that are applicable to the design process.

The major significant result of this analysis is to deny the technological lethargy of the building industry and the agencies that regulate it: innovations diffuse throughout the industry — despite the special characteristics cited at the beginning of this paper — in much the same way and at the same speed as in other industries. This result contains an important lesson for analysts of the construction industry who tend to be impatient of what they conceive to be the slow pace at which innovations are adopted in building design and construction. Such analysts know that the cost of replacing conventional apparatus is one reason for the delay in diffusing new technology in such capital-intensive industries as coal, steel, rail, and chemicals. They assume that innovations should progress faster in an industry which is less capital-intensive. But they forget

that the construction industry has a capital of its own special kind — the human skills of the labor force. A special kind of lethargy is built into this form of capital: building trade unions are duty-bound to prevent the obsolescence of this human-resources capital — a point to be discussed later.

The most arresting finding from this analysis of the diffusion of 14 innovations was that two had adoption histories very different from the rest. The two deviants — nonmetallic-sheathed electrical cable and plastic pipe for drain, waste, and vent lines in plumbing systems — are both in the "materials" category. The nonmetallic cable was accepted promptly (with a much shorter-than-normal introductory period) but moved only gradually thereafter into widespread use. In contrast, plastic pipe, commercially available to building users beginning in the late 1950s, was embraced instantly — an uncommonly rapid diffusion. Plastic pipe achieved in about 10 years a level of acceptance within 20 per cent of that enjoyed by nonmetallic cable, which has been commercially available for almost 50 years!

What can we learn by analyzing the factors that altered the rates of diffusion of these two materials innovations?

How Does the Industry Manage Change?

Though the building industry is diverse, dispersed, detached, and discontinuous, there is a single gate through which every technological innovation affecting public health and safety must pass if it is to be legitimately employed in the industry: the building regulatory agencies of state and local governments. These agencies are technological gatekeepers; by their decisions to permit or restrain use of innovative building techniques, they provide a publicly-accountable innovation management function. It turns out that the careers of the two innovations whose adoption failed to follow the usual pattern were differentiated at this stage. The local clienteles of these public agencies in the nation's states and municipalities participated with greater- or lesser-than-normal enthusiasm in the process of granting acceptance to two innovations. The deviances from the norms — nonmetallic-sheathed electrical cable and plastic pipe — were in the same direction, but the former moved inertially in the 1940s the latter explosively in the 1960s. The two cases bear further examination.

Seeking to understand this pattern, we asked over 1,000 regulatory agencies about the reactions of their clienteles to the 14 innovations during the agencies' decision period. They responded with a significant observation: officials of the United Association of Plumbers and Pipefitters were more exercised over the introduction of plastic pipe — an innovation that directly affected the marketing position of wholesalers, retailers, and manufacturers of metallic pipe and only indirectly affected plumbers' productivity — than they were over off-site preassembly of plumbing trees, an innovation with immediate consequences for the union members. Similarly, it was not the introduction of preassembled wiring harnesses that provoked the resistance of electrical union officials; rather, it was the introduction of nonmetallic-sheathed electrical cable which — like its counterpart in piping — displaced a traditional material. At least in these two cases union resistance was strongest where innovations based on a change in material portended a change in the underlying social technology — in the marketing, distribution, and transportation of the product. And since union representatives were the most visible resistors, they had the most important role in making an adoption controversial and difficult.

Our studies of others of the 14 major innovations added some useful and unexpected information on this subject: innovations affecting plumbers were the most difficult change in eight times as many localities as were changes affecting electricians. And, regardless of the specialty trade involved, changes based on materials were seen as "more difficult" in nine times as many jurisdictions as were changes involving methods.

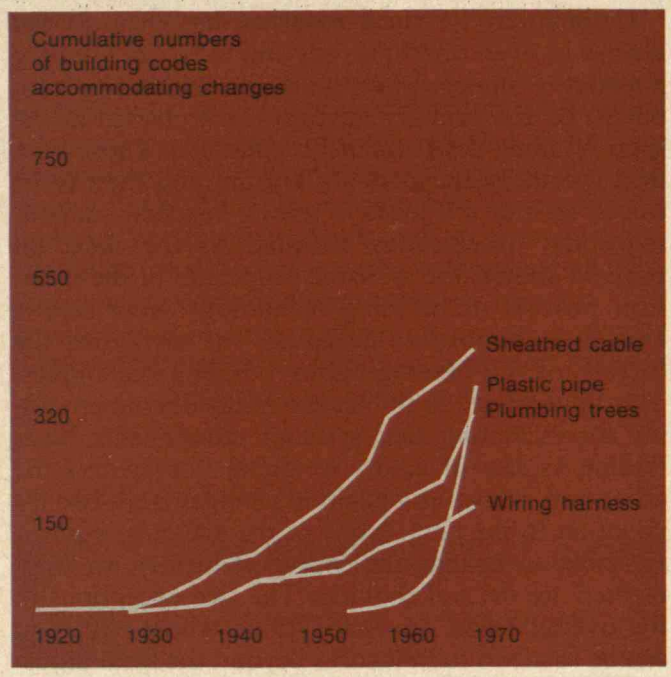
Why should "materials" changes be capable of mobilizing a wider coalition of resisting interests than "method" changes? Several reasons can be postulated:

☐ When a material change is contemplated, more of the regulatory agency's constituencies find they have something at stake, and so they mobilize.

☐ Materials changes are more "imageable," even to building professionals, than are method changes, which are often evolutionary and capable of partial application.

☐ Materials changes are unambiguous, immediately discerned by even the least informed; drain pipe is either plastic or cast iron. In contrast, a method change is an interval in a continuum of possible changes.

☐ Materials changes are usually relatively simple to understand and easy to communicate — not inconsiderable advantages in an industry as dispersed and



Diffusing technology in three stages and 30 years. Tradition holds that adoption of any innovation starts slowly, widens only when early users spread the word to colleagues and competitors, and finally slows again as its market reaches saturation. An industry's receptivity to innovation is inferred from the time — usually about 30 years — required for this process of technology transfer. Using this measure, the author proposes that in general the building industry has embraced new developments at least as rapidly as other U.S. idustries. (The data on the diffusion of innovations in industries other than construction is adapted from *Economics of Technological Change* by Edwin Mansfield.)

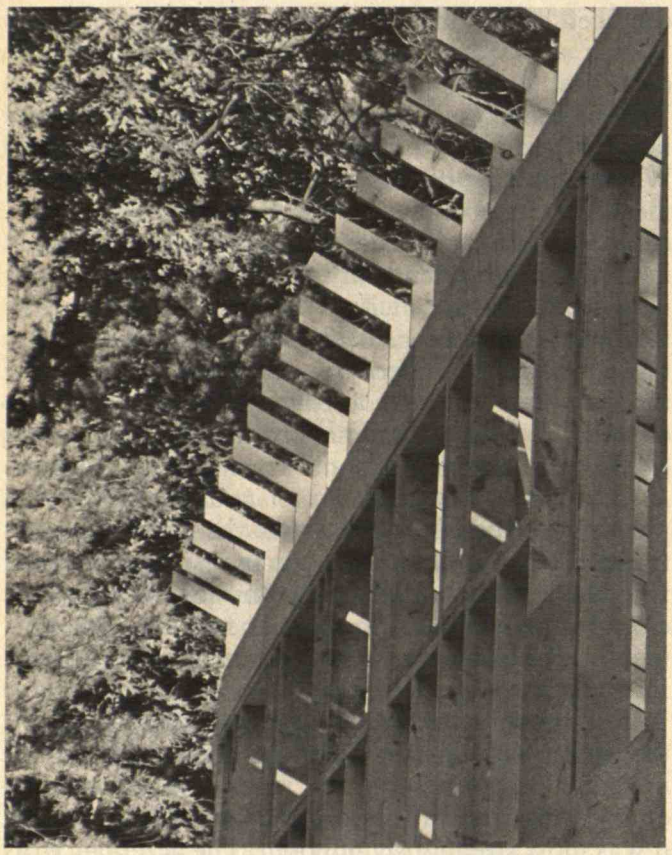
detached as building construction.

Both our special cases — nonmetallic-sheathed cable and plastic pipe — are materials innovations. Yet one progressed into application faster and with far less acrimony and disruption than the other. Why? One key difference is the existence of the metals shortage of World War II just as nonmetallic cable was coming into use. But an equally important issue was the existence in the electrical contracting industry of the Council on Industrial Relations, a national labor-management forum designed to "remove the causes of friction . . . by providing a forum for . . . settlement of controversies" between local chapters of the International Brotherhood of Electrical Workers and the National Electrical Contractors Association. There is no exact counterpart in the plumbing trades. It is clear that the electrical contractors' 60-year old Council on Industrial Relations formalized the conditions necessary for the diffusion of technological innovations in the dispersed building industries at a time when there was no precedent for rapid acceptance of new technology.

In contrast, consider the case of plastic pipe: even the most vociferous coalition of unions and building materials producers of recent years failed to stem or even to delay the diffusion of an innovation to which it was most strenuously opposed. The acceptance of plastic pipe was the result of coordinated efforts to mobilize *ad hoc* builder groups, reinforced by technical support, advertising, and lobbying under the auspices of the Plastic Pipe Institute (P.P.I.) of the Society for Plastics Industry.

No single actor among the hundreds of thousands — individual and institutional, private and public, voluntary and involuntary — on whose decisions rest the acceptance of new technology asserts enough control to abort a technological innovation. Despite that fact, the effort to single out two or three of the hundreds of actors for indictment has been a popular pastime among critics of the industry. Our studies of the construction industry, including the housebuilding subindustry, lead us to conclude that such scapegoating betrays an ignorance of the dynamics and complexities of the construction enterprise. The fact is that a plurality of interests in coalition have a stake in the advance of construction technology. The "frictions" that delay the evolution of building technology are far more complex than obsolete building codes and restrictive union practices, the most-frequently cited culprits.

A more useful formulation of industry's dynamic can be drawn by analogy with other systems in



which power and responsibility are dispersed among large numbers of actors, no one of which has more than a small fraction of the resources and power required to redirect the system as a whole. Our analogy is with democratic, multifaceted political systems, where hesitation in the face of technological innovation proliferates through the whole. The lack of a single dominant underscores the fact that the industry, like a political system, is greater than any one of its constituents, even the strongest of them. While local pockets of resistance occur the diversity and the fragmentation of power and influence within the construction industry assure there is no singular "veto group" sufficient to stymie innovation across the nation as a whole.

The Myth of The Obstructors

This finding, that the whole is greater than the sum of its parts, might seem a slight contribution indeed were it not for the pervasive of belief among industry critics in one or two key "obstructions" to technological progress in the building enterprise — the labor unions and the tradition-bound local building community, for example.

Unions may be vocal resistors, but they do not always or even often prevail; and the local building interests — material purveyors and builders — turn out to be the primary advocates for change in the local building departments' regulations. Those who seek specific scapegoats are wrong; and their error can be serious if it leads to wrong-headed and, consequently, mischievous reforms. As the chart on page 54 shows, the systemic properties of the diffusion process in building technology were strong enough to impose a "discipline" of sorts over the careers of 12 heterogeneous building techniques. This "discipline" is in fact the result of countervailing forces among that system's components functioning as sets of actors weighing one against the other, sets whose composition changes from one innovation to the next. None of the actors by itself is *sufficient* to change the course of history, so fragmented are the stakeholders. The two exceptions to the overall trend are innovations whose diffusion can be ascribed to influences beyond the local industry: World-War-II materials shortages influenced the cable case, and the P.P.I. coalition, the pipe case. So we conclude that, strong as the homeostatic properties of the building enterprise are, the system *does* respond to external perturbations, particularly to positive pressures for technical innovations. The system is notably indifferent to externally mobilized resistance to change.

The efficacy of the Council on Industrial Relations is now recognized by the emergence of other similar bodies among the building industries. These joint labor-management councils, once concerned solely with wages, hours and working conditions, now specifically refer to their roles as monitors of emergent technology. The pipe case makes it clear that such associations can be instrumental in accelerating change in the regulatory system.

Indeed, the exceptional acceptance of plastic pipe and nonmetallic-sheathed cable provide precedents for new, creative roles — independent or cooperative — for both industry and government. Industries can continue to serve their historical function as agents of technological change. But such industry endeavors need the legitimizing presence of the building-using public in their deliberations. The addition of direct consumer participation would neutralize charges that such groups are dominated by the industries and at the same time would impose a mandate broader than the usual preoccupations with wages, hours, and working conditions of joint labor-management boards. Such consumer partici-

pation in the management of new technology will clearly advance the public interest.

Responding to arguments such as these, Congress in 1974 created the National Institute of Building Sciences; the fledgling institute received its first appropriation in 1978 and expects to be fully self-supporting by 1983. Its mission is to nationalize the building regulatory process and accelerate the assimilation of new and existing technology, thereby constraining costs and improving performance. The participation of both public and private groups is necessary. Congress has done its part, and the next step is up to the building community.

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Defense for a Small Planet: An Interview with Philip Morrison

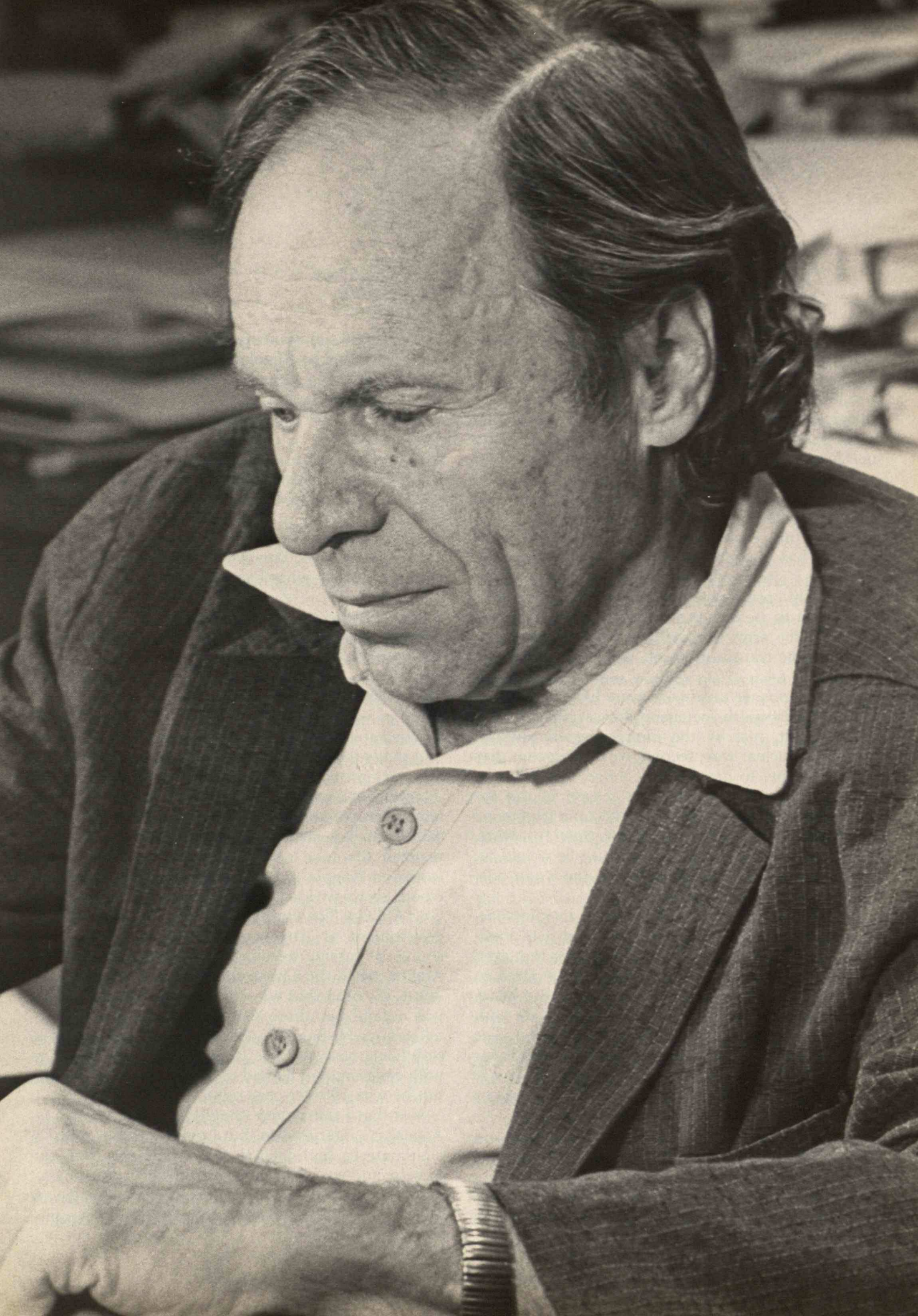
"Our resources are limited and we have too much in defense. We need to worry about the broad social health of the country more than the military threat; and indeed our own military is becoming as serious a threat as anybody else's."

As a young physicist, Philip Morrison was a member of the Manhattan Project. For him and for most of his colleagues it was a wrenching experience: first the excitement of an unparalleled technical challenge to harness the elemental physical energy of fission; then suddenly, with that challenge fulfilled, the need to cope with responsibility for a devastating, inhuman destruction.

Ever since then, Philip Morrison has sought rational moderation in U.S. military commitments — especially in those relating to nuclear arms. Meanwhile, Professor Morrison has gone on to become a distinguished theoretical astrophysicist, a leading proponent of the search for extraterrestrial life, and a uniquely eloquent interpreter of science. For these and other achievements, Professor Morrison, after nine years on the faculty at M.I.T., was honored in 1973 with the title of Institute Professor.

It was four years ago that Professor Morrison, with six other members of the Boston Study Group, began an extensive review of the U.S. defense program. Their goal was to understand "the forces and spending which would safely support a truly defensive U.S. military posture." Their conclusions were summarized last spring in *The Price of Defense: A New Strategy for Military Spending* (1979: New York Times Books), a book which brings out of hiding the grave but elusive subject of modern warfare for the "attentive, general reader." Just as it was published, a *New York Times*/CBS survey revealed that 64 per cent of Americans have no opinion on SALT II because they feel almost wholly ignorant of the complex issues involved.

Intrigued by the Boston Study Group's findings and troubled by that statistic on taxpayers' lethargy, Susanne Fairclough of *Technology Review* resolved to explore the issues of defense policy raised by the Boston Study Group, and some other related topics, in detail with Professor Morrison. Her interviews leading to the following conversation took place during the summer, when the news of SALT II and debates on defense policy were often eclipsed by the impending fall of Skylab. The circumstances roused Philip Morrison's vigilant sense of proportion: "Every day something falls out of the sky. . . . It's true



that Skylab is larger by five- or tenfold, but it gets a million times more publicity."

Fairclough: In *The Price of Defense*, you and your colleagues propose cutting the U.S. defense budget by 42 per cent. That's a radical proposal. Why are such large reductions needed?

Morrison: The fundamental reason is that the world doesn't get any bigger, but the weapons get stronger and more numerous. So sooner or later, military spending has to decrease. In short, you can say the arms race is itself a danger, entirely apart from "the enemy." Up until now, people have only considered the enemy to be the problem; but eventually it's clear that the arms race will be the main problem. There's some transition point; we argue we're past that point.

The weapons we invent are more likely to destroy us all than vanquish the enemy for several different reasons: first, just by the unprecedented physical damage in nuclear war; second, by the fact that they push an enemy to develop still more; third, by the fact that they induce a lack of reason in the apprehensive opposition, who may become frightened and lose control. The history of previous wars, which were not as cataclysmic as this one would be, shows very clearly: to induce fear is the worst possible way of averting conflict.

In addition, there is the temptation to intervene, which we had in Vietnam. We can't end that possibility because Americans have such power that even a small fraction of our force is large compared to that of a quite respectable military power. But by reducing our force to something commensurate with our problems, at least you inhibit intervention. The American doctrine used to be a two-and-a-half-war doctrine. It's now more like a one-and-a-half-war doctrine. And we'd like to cut it down to a 1.1- or 1.2-war doctrine.

Fairclough: What do you mean by a one-and-a-half-war doctrine?

Morrison: It means we fight a big war against the Russians and simultaneously a small war against the Vietnamese or the Angolans or someone else. In the two-war doctrine, you plan to fight the Russians and the Chinese at the same time! Neither of these seems sensible.

Fairclough: If we disarm, wouldn't the Soviets then feel they could intervene more easily in areas where the U.S. and the Soviets are in contention?

Morrison: I think that if the Russians were to intervene on a big scale they would get badly tired of it, which is exactly what happened to us.

Fairclough: Do you think there's a possibility of the United States entering into another war like Vietnam?

Morrison: I think that's always in the balance as long as we're so well prepared to do it. We've avoided it for a few years under President Carter, and that's the best thing I can say about Carter. I'm also very proud of the Senate's wise decision not to intervene in Angola — not even in a covert way (intervention was urged on us very strongly by great statesmen like Henry Kissinger). It's not generally realized that one of the functions of the Cuban troops in Angola (when Cuba had a few thousand troops there) was to guard the oil installations of the Gulf Oil Co. The Gulf Oil Co. pays royalties to the government of Angola — oil was the principal source of foreign exchange. So the government of Angola asked the Cuban forces to protect that situation. It's been that way for four or five years. This was noted by Andrew Young at one point, most intelligently. He said the Cubans in Angola act as a stabilizing element. The Republicans drenched him with criticism and he had to take it back a little bit, but he was 100 per cent right.

Not that I think there should be Cuban troops in Africa; it's intervention. But I understand it: when a legitimate or semi-legitimate government asks you to help, and you've been allied with that government for years, you help them. That's the way we've always done it. Intervention is clearly a very compli-

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cated issue. Why haven't we intervened in the Persian Gulf to preserve our supply of oil? The reason, in my opinion, isn't that people think it would be unjust. Primarily, it's because you simply cannot secure the supply of oil from the Persian Gulf by military means. Physically, you can't do it. Oilfields are too vulnerable, the straits are too narrow; and even rather modest hit-and-run military forces could reduce the output of the Persian Gulf by at least a factor of two — maybe a factor of five. There is no way to keep full oil production going in wartime no matter how many American troops you put there — even if the Russians did nothing except supply material to their friendly armies. You can't maintain delicate economic arrangements under the conditions of wartime. Yes, you could deny the Persian Gulf to the Russians — easily. But that's not the same thing.

My coauthors and I agree that the United States should not be isolated. Rather, we think the U.S. should recognize that the world is much more complicated than it used to be and that the United States is not the monopolist of military force that it once was. We have reached the point where military force is not only risky but will no longer buy us what we think it will. And therefore to be overprepared with it is a mistake. We want to deal with the Persian Gulf nations, so we better give them good terms or use economic sanctions. We should develop alternate sources of energy and do a hundred different things. But the last thing we can do is send troops there; it just isn't going to work.

In our book, we don't propose to solve all diplomatic issues. We just say: let's look at what the military can do and what they're trying to do. We come to the conclusion they're trying to do too much by the wrong means; it's risky to go ahead that way, so we should reduce military expenditures: a very modest proposition. That doesn't represent a complete solution to United States problems at all. But it is a necessary condition for a more rational approach towards international affairs.

Fairclough: What are the main areas of the defense budget in which we spend too much?

Morrison: Aircraft carriers and marine amphibious forces are the main tactical areas where we receive very little utility for the gigantic sums being spent. So we recommend a sharp cut: from three marine divisions and air wings to one; and from 13 aircraft carriers to three or four. A third area, perhaps, is the Army light divisions — ground forces meant for intervention far from the Russians. It doesn't seem we need so much force of that kind and so we recommend cutting from seven divisions to three.

Fairclough: Frank Press, the Presidential Science Advisor, has stated that the administration plans a large increase in high-technology research and development for defense. Do you foresee an increase in the use of "smart" weapons?

Morrison: Yes, and so does the Department of Defense. We agree with them that this is clearly the wave of the future, especially for ground and naval offensive battles, and this will eventually favor defense as well.

Fairclough: Why is that?

Morrison: The principal weapons of offense at the moment are fast, mobile tanks and aircraft. But those are becoming more vulnerable because of inexpensive weapons which can track and hit using sensing devices and miniaturized circuitry for guidance. It begins to seem better to give up the mobile weapons, simply to stay put where you are. Then when the enemy comes to you, you can make trouble for his very expensive aircraft and his tanks. (The jeeps and light ground forces using these cheaper weapons are not as good for the offensive as heavy tanks and aircraft.) The same situation is true at sea. The little boats with short range that carry these weapons now begin to threaten the big boats that can cross the ocean to attack. The Chinese have a thousand patrol boats, for example, but nobody thinks they are going to come to California. They're meant for defending China's own coasts. That's a legitimate purpose, and therefore it's good that defense is now more powerful, that bigger ships are in-

creasingly afraid to come near those ships.

This favors the small man in some sense, assuming he has this technology available, and it clearly favors the defense. A highly mobile, highly independent system is characteristically usable as an offensive system — it can move 1,000 miles away from its home base. The others can't move more than 100 miles from home, and therefore they're more defensive in nature. They don't fight well in the enemy's territory; they fight much better in their own.

Toward the end of the Vietnam war, for example, the Vietnamese had SAMS (Soviet surface-to-air missiles). These are cheap little weapons (costing a couple of thousand dollars each), yet one of them can be deadly against a helicopter which costs half a million dollars or more. In response, we began to pull our helicopters back from any contact with the enemy, and we used them only where it was quite certain the enemy wouldn't be (to move the troops up closer to the front, for instance).

Fairclough: What changes do you propose for the nuclear weapons arsenal?

Morrison: Intercontinental ballistic missiles are rapidly becoming more and more vulnerable; therefore we say get rid of most of them. The primary deterrent should be under the seas, where it's still very hard to find and destroy a missile-launching craft. Land and airborne missiles should be a kind of hedge. Moreover, we propose to reduce the latter gradually, to end up with some land-based missiles and hardly any aircraft. Since there is a small chance — not a very real chance — that something drastic would happen to make submarines more vulnerable, it would be a mistake not to have some kind of backup. We say keep one or two hundred of the land-based missiles; and arrange them to fire on warning (but only after the destruction or compromise of the submarine-based weapons). You still have a sure deterrent, even though these weapons are vulnerable; but you don't count on them.

Fairclough: What of the concern that submarines are not accurate enough?

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Morrison: Why do you need accuracy? You only need it if you want to attack hardened silos, and the only reason for silo-busting is if you're firing first. Submarines are accurate enough to attack military targets — like submarine bases and aircraft bases — as well as factories and urban populations. Plenty accurate enough! And I'm sorry to say that the new submarine-launched weapons will probably be as accurate as the current land-based missiles in five to seven years. In that sense, the argument will disappear.

But we see no reason for increasing such accuracy — it's only dangerous. It only increases the desire to make a first strike.

Fairclough: So you don't think that the "strategic triad" is necessary.

Morrison: That's right. I don't think it's a fully reasoned idea at all. It's largely a device to maintain the strength of the existing forces of the armed services. I'm not saying it has no justification at all; all such things have half-truths in them. They're just not worth what you pay — neither the money nor the risk. At the moment, we pay for the Minuteman — and explicitly for the MX — because of the belief that there must be a race for counterforce and first-strike capability. That seems to me a very wrong thing to do.

Fairclough: Why do you think the MX played such a prominent role in the SALT hearings? Does it give us any advantage?

Morrison: Well, there's no question that it's a payment to the right wing so that they'll vote for SALT. As to whether it gives us an advantage or not, that's not a question. Compared to what? And for what purpose? The people who are for it certainly think it provides an advantage. In fact, I think some of its most enthusiastic supporters want to use the MX one day to make a first strike against the Russians. So it gives us an "advantage," but one that is very dangerous. The other people who support MX are either unclear, make a high estimate of the value of its symbolism, or simply recognize that the Air Force needs something to do.

I think it's quite possible that before too long, when the work has progressed a little further, we might see that the mobile feature won't work. They'll drop that property. That should, of course, end the whole thing because that's what it has been sold for. Instead, they'll put the improved MX missiles right back into the old Minuteman silos, on the grounds that MX is a bigger, faster, more accurate rocket — just as vulnerable but more capable of a first strike against the Russians. This would be the worst possible consequence. Congress acted explicitly against this two or three years ago, but the supporters will try to overcome that. That will be a political battle well worth fighting.

Exactly this happened once before in a related way. When MIRV (multiple independently targetable reentry vehicle) was being proposed to Congress it was said to be essential because the Russians were building a powerful anti-ballistic missile system. Well, both the Russian and the American anti-ballistic-missile systems disappeared, but we still have the MIRVs, now turned to offensive use. We simply give them real warheads, not decoys, so they can attack many individual targets. That's responsible for much of the trouble today, because the Russians, naturally, were able to catch up five years later to do the same thing. That's the way it goes. The whole nuclear system has been raised to a greater pitch of danger, at much greater expense, and nobody's gained anything. And I fear this is going to happen all over again with the MX.

Now suppose, for the sake of argument, that we do need more missiles, safer from the Russian missiles. Then I would say, let's put them in submarines. Why don't we do that? Indeed, Frank Press proposed the idea. But it was defeated — largely because the Air Force wouldn't get the missiles. The people who want more missiles, it turns out, are allied with the people who just want the Air Force to have a strong mission. The two together, then, make a powerful political force. If the Air Force ran submarines, there'd be very little doubt that they'd be quite happy to have the missiles in submarines.

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Fairclough: Let them have a couple.

Morrison: I have often proposed an Air Force Submarine Corps.

Fairclough: Do you think that SALT II reduces the prospect of nuclear war?

Morrison: It's a tricky business. It does, but I'd much rather put it the other way around: The rejection of SALT II would increase that probability. SALT II doesn't go very far, but it's going in the right direction. At least SALT II has the motivational value of showing that we intend to do something. Therefore, it's valuable to pass it. Not because it brings us so much, but because if it's defeated that sends an entirely different signal out to the world.

Fairclough: Civil defense is finding new support through SALT II. Is there any need for concern that the Soviets are making plans for evacuating their cities in the event of nuclear war?

Morrison: They haven't done much in reality. Senator Jackson, T. K. Jones of Boeing Aircraft, the Committee on the Present Danger, and a lot of other people have claimed that there is a major Russian effort. They haven't offered much evidence; the Pentagon and the C.I.A. have denied it. Our correspondents in the Soviet Union deny it.

The Soviets have some system, and we have a system too; their system is probably somewhat larger and better than ours. But there are no real drills, no activity of that kind.

Fairclough: The defense cuts you propose would take 3 million people out of military jobs over a ten-year period. How could that be accomplished?

Morrison: The argument is easy to make that the average job in the United States uses more people than the average military job because the military job is so technical and uses so much hardware. Therefore, if you were to displace a certain amount of military dollars, there'd be more jobs open in the civil economy.

That was not the main point of our book. Somebody else would have to make a detailed economic study to see just how this should be managed. We simply said: it's not an insuperable problem; the scale of it is manageable. We felt obliged to show that the U.S. doesn't need a great deal of the military hardware it produces — there's no point in making something dangerous, and which you don't need, just to employ people. Instead you might make something else you don't need, or something that's a luxury, or something that would actually have permanent value.

Fairclough: What impact can science have on world relations?

Morrison: There's no simple answer. Nineteenth-century optimism suggested that the more people knew, the better they would regard each other. That may not be true at all. There are counter-tendencies which are just as strong, so that the growth of science has not meant the growth of peaceableness or reason in society as a whole. What it tends to do is put power in the hands of the powerful. Sometimes they do well with it; most often they don't.

If you ask what unites every state and every revolutionary movement, it's one thing: their people carry automatic weapons — a universal technological good in the service of power. If you have power, you have them. If you want to take power, you have them. You don't do it just by getting together, or by meditation, or by putting out leaflets. You have to do lots of other things, and what you always remember to do is to have your automatic weapons.

Fairclough: Aren't scientists responsible for such "technological goods" as automatic weapons, and for the awesome weapons in the world's nuclear arsenals?

Morrison: Scientists don't make rockets and they don't make warheads — the government does that. Congress pays for them, and industries manufacture them. Yes, scientists certainly are responsible for the original input, but a huge consensus is required before it's all made a social reality. And against that

consensus, there is not much an individual can do. I think the only thing to do within the structure of our society is to promote public education — to speak about it, write books, argue, and point out the difficulties.

An interesting question is: Why isn't there more concern about it? It's all suppressed. Very few people place any kind of weight on it. There is much more activity against nuclear reactors, which are entirely unimportant, in my mind, compared to nuclear weapons.

Fairclough: Why do you think that is?

Morrison: I think people have given up. Nationalism is such a powerful force. There's no way to change it. With reactors, maybe you can get the reactor to go somewhere else; it has a local habitation. I think people do recognize that there is a weapons problem; they've just not had any success in that direction. It's really very strange: there are 70 reactors in the United States and there are 35,000 nuclear weapons, each one of which is considerably more dangerous than a serious reactor accident. On the 30th anniversary of Hiroshima in 1975, a big statement was circulated. It said: now it's the 30th anniversary of Hiroshima and therefore we should not have any more nuclear reactors. I didn't understand the logic of that. I could understand the logic of saying "now we shouldn't have any more nuclear bombs," but they didn't mention that at all. So I wouldn't sign the statement.

Fairclough: Public opinion did change after years of experience in the Vietnam war. Can experience (or, better yet, its equivalent) come to bear on the issue of nuclear weapons?

Morrison: It's certainly true that the Japanese government has had a very different policy towards nuclear weapons than almost any other government because of incredibly strong public feeling that arose there (in spite of a strong defense posture). I don't think the Japanese are going to have nuclear weapons for a long, long time — until the generation which experienced the war is gone.

I think that the American experience in World War II was very unfortunate from the standpoint of the post-war world. Americans didn't encounter war at all in America. That gave them a very unsatisfactory view of what warfare is like.

Fairclough: Do you think it's part of human nature to have wars?

Morrison: Well, it's certainly in the nature of our societies to have war. I don't know that it's in people's nature. War was not a concept among the Eskimos — they were rather surprised by it. They knew about murder; they didn't know about war. They couldn't, because war would mean losing the game animals, thus making Eskimo society very difficult to maintain. Human nature is a plastic and malleable thing. I impute human nature to society. Murders are going to happen among people, as well as bad temper and so on. But war is none of those things. I had no bad temper when I was in the war — I had a much more abstract frame of mind.

The trouble is that there isn't enough direct experience, especially in these rather subtle matters like international relations. That's the hardest problem — that societies have means of interacting now which are just not within the experience of the average person. So he or she can only form a very vague understanding of what these interactions mean.

Fairclough: Could the educational system help by integrating experience more with quantitative study?

Morrison: Sure, it has to be done. It means that words and calculations and diagrams and memorizing principles of physics have too great an emphasis compared to the actual experience of what all these things mean. The schools should depend more heavily on real experience and less upon symbolic experience.

It's a very clear historical development. When the average family was a farm family, people had plenty of material experience. They knew about life and death, the growing of seeds, and the weather; the environment was very rich. But what they didn't

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have was a big flow of symbols. So schools set out to rectify that. Let everyone learn to read and deal with symbols and see pictures of faraway places. Very sensible thing to do. But now it's caught up. Now the people in the city have no such experiences. They work in their houses or they go to an office. The environment is air-conditioned; the windows do not open. They rarely see the moon or the stars or a horse or a cow. Some think milk comes from bottles in the supermarket. And they have a flood of images: thick newspapers every day, television, and a computer that tells them what to do at work.

Fairclough: Is the government relying more on quantitative models and less on experience to make policy decisions?

Morrison: Actually, I don't see that happening. They talked about fighting the Vietnam war on computers, but they didn't actually do it. It was the experience of sending the men out there that made the difference, and the computer simulations meant nothing in the end. "Objective" arguments, by computer and so on, are usually invented by people to support the policy they wanted to carry out anyway.

Fairclough: Do you think defense-related research and development is an appropriate role for scientists at universities?

Morrison: No, I don't. In our book, we recommend a sharp drop in the basic research activities of the Department of Defense. At the moment, D.O.D. money is not overwhelming in scientific research. For example, D.O.D. is about third or fourth in supporting M.I.T. research. Health is the first, the Department of Energy is second, and then D.O.D. (if it's third, that's only because of old connections). Indeed, a few years ago, the Congress passed a resolution — called the Mansfield Amendment to the Defense Appropriations Act — which said that the D.O.D. should not support scientific investigation which was not relevant to the D.O.D. mission. And that cut off an awful lot of things they were doing.

It's a mistake for D.O.D. to have a lot of influence on research. Even for applied research, we favored setting up a special institution, a National Technology Foundation, which would support technological innovations but would not be quite so tied to the interests and goals of the D.O.D.

Fairclough: How will a change occur in our present posture towards defense?

Morrison: I have no special prescription for that — it's obvious there has to be a change in public opinion. That means newspaper editorials, letters to congressmen, organizations, city councils, and a hundred different media saying, "Our resources are limited and we have too much in defense. We need to worry about the broad social health of the country more than the military threat; and indeed our own military is becoming as serious a threat as anybody else's."

The best we can hope for is that a movement will slowly build. And there are a few signs. SALT is very good for that, not because it's important in itself, but because it directs people's attention to these issues — maybe not as clearly as it should, but a little bit.

No solution will be reached by one act or resolution. There has to be a whole realignment of interests. Candidates coming up for public office who will pledge to do this; that's the way to go. Remember that the first ones may not carry through. In fact, Carter is one like that. He talked a good game in this direction; maybe he really wants to do it, but he's caught in so many influences of the past and so much powerful structural determination that there's not a great deal he can do. For a little while, the test question is going to be MX. I hope MX will not be deployed, just as B-1 was not deployed, and that could be a marker of the opening up of the new world.

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Trend of Affairs

Trends This Month

Space Exploration

Voyager 2: The Jovian Moons Revisited

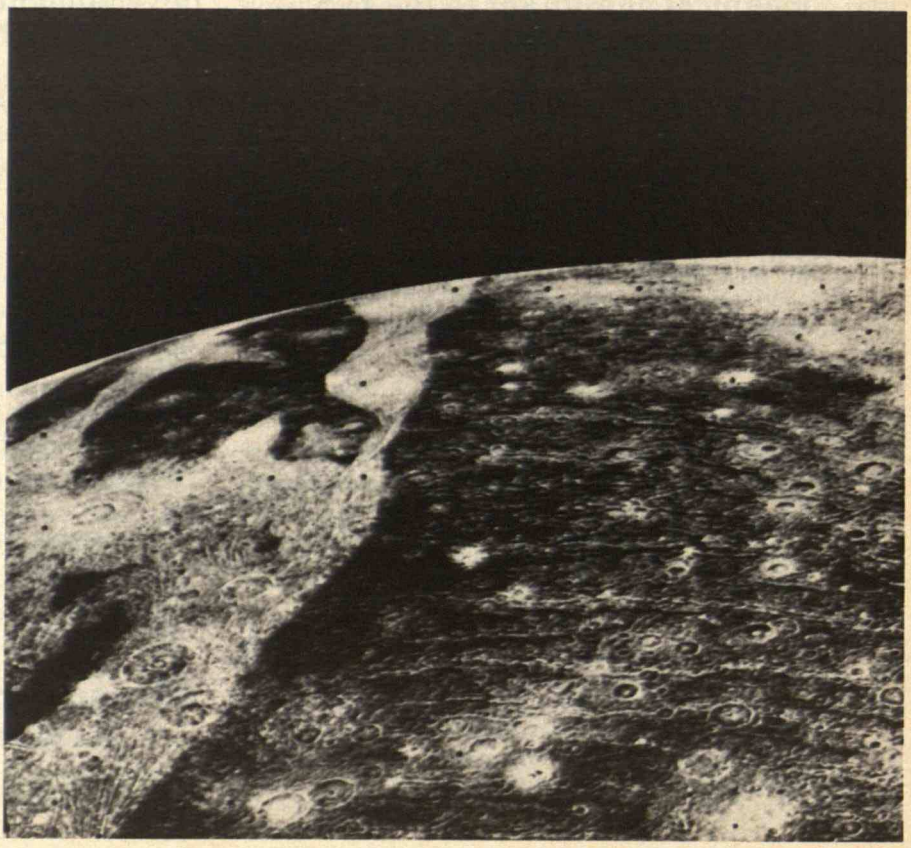
"The sense of novelty would probably not have been greater had we explored a different solar system," wrote the Voyager Imaging Team soon after *Voyager 1*'s March flyby of Jupiter and its incredible moons. And the impression is strengthened by further analysis of *Voyager 1* data and *Voyager 2*'s flyby in July.

Callisto, outermost of the Jupiter's Galilean satellites (the four large, planet-sized moons of Jupiter; there are in addition nine or more smaller ones), is the least geologically active major moon or planet ever seen; Io, the innermost Galilean, is the most active.

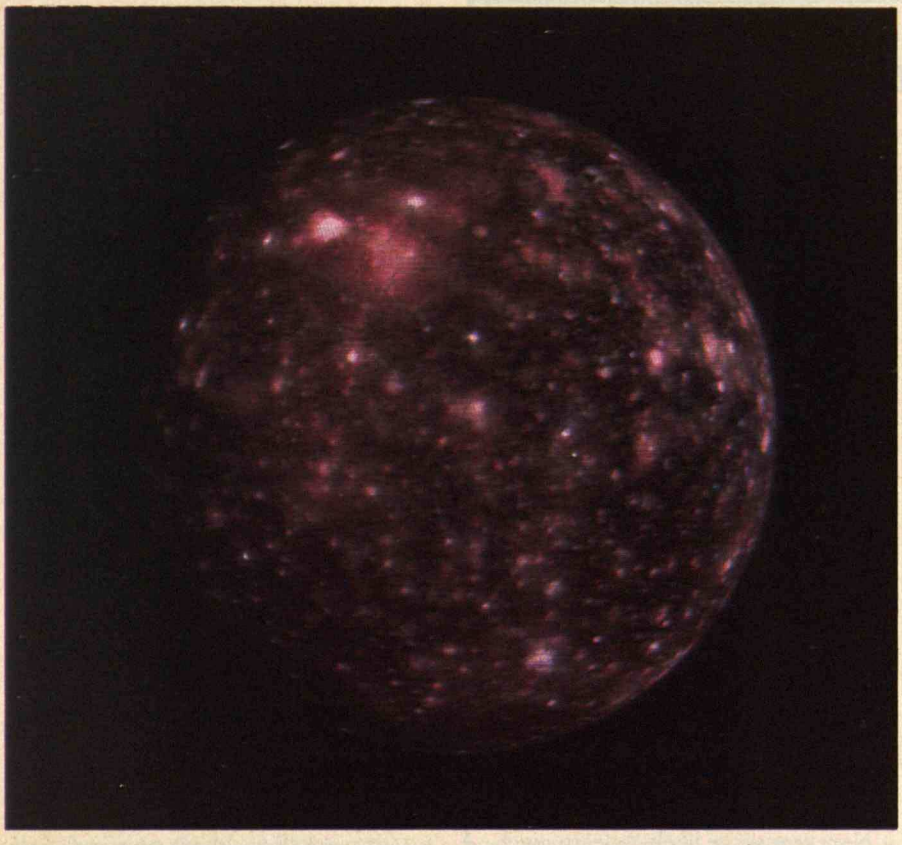
Made largely of water (frozen or liquid), Callisto has a surface totally covered by ancient meteorite craters. We can say that now of both hemispheres, for *Voyager 1* viewed only half of Callisto close up (roughly the hemisphere that faces Jupiter) and *Voyager 2* saw the opposite side.

A viewer's first impression might be that far fewer very large craters (hundreds of miles across) formed on Callisto than on Earth's Moon, Mars, or Mercury, implying different meteorite-size distributions in the outer and inner Solar System. However, Callisto's weak, ice-logged surface could have allowed crater walls to slump and floors to rise after formation, until the craters look almost two-dimensional. On worlds made of rock, large craters tend to remain detectable as large, regional depressions. On ice worlds like Callisto and Ganymede (third and largest of the Galileans) the depressions disappear. Also, small meteorites are commoner than big ones, so big craters tend to be obliterated by younger, small ones.

It's therefore significant that the three relatively large craters visible on Callisto as large, bright patches surrounded by multiple concentric bright rings — the largest is 1,800 miles across — are the three youngest surface features of their size. (Their age is inferred from the number of younger small craters superimposed on them, which is only 1/3 the average for Callisto.)



The largest of Ganymede's ancient, cratered regions. Remnants of a multiringed basin some 5,000 miles in diameter can be discerned — large enough to cover an entire hemisphere. The rings of this basin are twice as close together as are similar features on Callisto, suggesting that Ganymede's crust was the weaker of the two. An impact crater that once stood at its center has been destroyed by the subsequent formation of grooved terrain, but has been estimated at 600 miles in diameter. (*All photos: National Aeronautics and Space Administration Jet Propulsion Laboratory*)



Top left: The side of Callisto that faces away from Jupiter. Near-ultraviolet is seen as blue, blue as green, and green as red. The bright patch at top center is a multiringed basin. The brighter portion of the rings may be ice or some other light-colored material, which underlies its dark surface layer. Note the many collars of ultraviolet-reflective material around craters toward the right and their absence in the left half of the image.
Top right: Europa, a world locked in the grip of a permanent global ice age. The dark lines are up to 3,000 miles long and less than a few miles wide. Note the two bright (ice?) ridges at bottom center.
Left: The side of Ganymede that faces Jupiter, from four million miles. All the Galilean moons, and Amalthea, keep one hemisphere toward the planet. Blue polar regions and a bronze-colored equatorial belt, suggested by *Voyager 1* photos (taken from 400 million miles distance) can be confirmed.

Pioneer 11 and a Titanic Deep-Freeze

Does life exist on Titan, Saturn's largest moon? Probably not, judging from temperature data received early in September from the *Pioneer 11* space probe.

For the first time, the 3,600-mile-diameter, planet-sized moon has been scrutinized fairly close-up — on the order of one-quarter million miles away. By coincidence the flyby occurred in the 350th anniversary year of Christian Huygens, who discovered Titan in 1655.

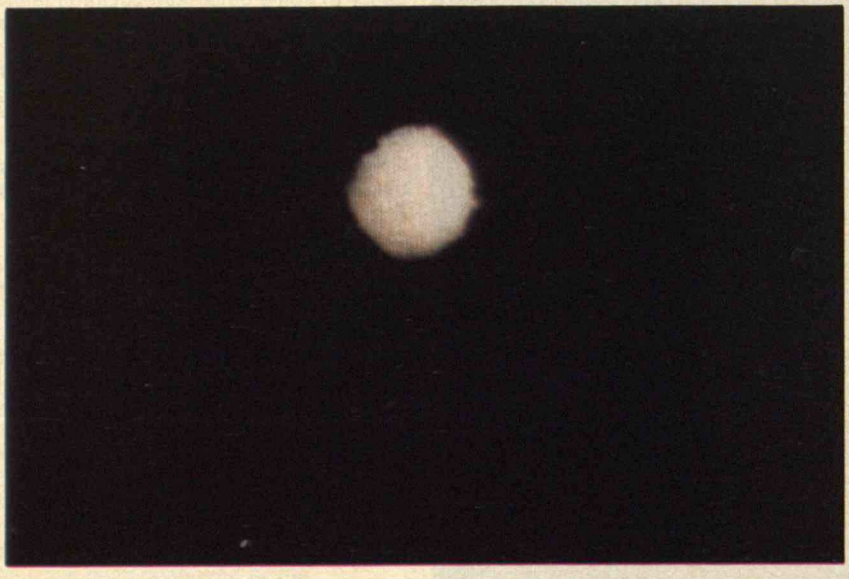
At first, *Pioneer 11*'s signals were feared drowned out by transmissions from the Soviet satellite *Cosmos 1124* (an earth-orbiting, early-warning device). The Soviets had always cooperated by turning off such transmissions when they might interfere with our planetary missions — when asked. But this time, the National Aeronautics and Space Administration simply failed to ask.

Good news: we got most of the data anyway. It seems that Saturn's mass — imprecisely known — failed to bend the spacecraft's trajectory as expected, causing the *Pioneer* transmissions of Titan data — at first thought lost — to come about a half-hour later than planned. By that time *Cosmos 1124* had almost moved out of the way and only 20 per cent of *Pioneer 11*'s message was lost in Soviet noise.

Bad news: Titan is much colder than earth-based observations (and hopes) had indicated. Andrew P. Ingersoll, Associate Professor of Planetary Sciences at the California Institute of Technology and principal investigator on *Pioneer 11*'s infrared radiometer, puts Titan's temperature at about −325° F. Professor Ingersoll says that it isn't clear to what degree the data were influenced by conditions on Titan's surface or, say, by a high, cold layer in its methane-rich, true atmosphere.

Very recent Earth-based radio astronomy data indicate that the surface of Titan is only 25° F warmer than the *Pioneer 11* reading. Too cold for Earth-like life, Titan may still have an interesting pre-life organic chemistry. Certainly its exotic composition — mostly frozen water and ammonia — promise weird "unearthly" geology and meteorology.

Next year we're likely to learn much more about Titan: *Voyager 1* will pass a scant 2,000 miles above the mysterious cloud tops. — *Jim Loudon* □



The first look at Titan, Saturn's largest moon by *Pioneer 11* from 230,000 miles on September 2. At this point, the spacecraft was 800,000 miles from Saturn — and 963 million miles from Earth. (*Photo: N.A.S.A.*)

According to geologist Laurence Soderblom, deputy leader of the Voyager Imaging Team and a U.S. Geological Survey scientist, the rings are fractures in the ground caused by the shock of meteoric impact. But they are more closely spaced, more numerous, and extend much farther from the central crater than do similar structures on rock worlds. A central bright patch found in each of these features is now believed to be the original crater, otherwise buried under its own ejected debris. All these phenomena may be due simply to the lower strength of the icy surface.

Ganymede had its Jupiter-facing hemisphere scrutinized by *Voyager 1* and the other by *Voyager 2*, which came twice as close to the moon as did *Voyager 1*. The additional detail shown in *Voyager 2*'s image has broken down the simple post-*Voyager 1* model we had of Ganymede. In that model Ganymede's surface was cleanly divided into two terrain types: large, heavily cratered, Callisto-like patches bounded by younger, brighter strips whose surface consists of strange, parallel, curved grooves. After *Voyager 1*, it was believed that the grooved regions were huge fault zones. We've now advanced: we don't know what they are.

Voyager 2 shows that both types of terrain have a range of ages, though the grooved regions are younger on the average; that parts of the supposedly "undisturbed" centered terrain show what look like incipient grooves; and that a third terrain type, mountainous regions younger than the other two, exists.

If we assume that regions on Ganymede with more topographic relief are the younger, then we can construct the following reasonable geological history. The ancient craters flattened soon after they formed, and the crust, which was especially weak then, became more rigid as time went on. Because Ganymede's youngest, mountainous, regions are old compared to the maria (large lava sheets) on Earth's Moon (which formed when the Solar System was about one billion years old) we may conclude that active stages in Ganymede's history took place long ago. The best estimate has it that Ganymede died well over 3 1/2 billion years ago.

Europa, second and smallest of the Galilean moons, was viewed closeup for the first time by *Voyager 2*. No vulcanism is evident, but there is a scattering of meteorite craters — enough that the age of Europa's surface could be, as a rough guess, half a billion years (as compared with less than one million years for actively volcanic Io.

A revised estimate of Europa's density, from *Voyager 1* data, implies that this moon is made mainly of rock. The outer 20 per cent of its volume, however, is water — frozen at the surface, but probably (because of the tidal heating) liquid underneath. Europa's surface would thus be weaker than the partially frozen surface of Callisto and Ganymede. Indeed, Europa is the flattest world ever seen; its highest mountains are ice ridges a few hundred feet high, and it has no valleys at all.

Most of Europa's surface is seamed by thousands of puzzling brown lines. Their pattern suggests cracks, but they show no topographic relief, no evidence of fault motion, horizontal or vertical, and all appear to be the same age, as if they formed in a single event or short period.

One theory is that the global icecap once expanded (due to freezing of the underlying water?) and formed the cracks, which were then filled in with a darker material (water-borne debris?) from below. (At least one of the Europan craters is surrounded by dark streaks of ejected debris, suggesting an impact that had excavated such dark material from a layer not far under the surface.) The filled-in cracks were thus prevented from closing again when the icecap shrank and formed the ice ridges and lines instead.

But if you'd like a completely different theory, try this: the ridges are material more resistant to erosion than the rest of the surface, so they slowly emerged as the remainder of the surface was slowly eroded from around them. What could erode an airless world like Europa? According to Laurence Soderblom, it could be erosion on a microscopic scale. The subatomic particles that comprise Jupiter's intense radiation belts could have collided with and removed over half a mile of ice over the 4 1/2-billion-year history of the Solar System (assuming, of course, the radiation belts always were as they are now). This process would be important only for Europa; Io's surface is reworked far more rapidly by vulcanism, and the density of the radiation belt is too low at Ganymede and Callisto.

Amalthea, closest to Jupiter of all its moons, is far smaller than the Galilean satellites (it would just about fit into Lake Huron) but has its own surprises too. *Voyager 1* found that Amalthea emits 30 per cent more heat than it receives from the Sun, raising its temperature from the −235° F expected for a body at its distance from the sun, to a balmy −125° F. Amalthea is far too small to be heated either by the tidal mechanism proposed for Io and Europa (whose efficiency increases as the *seventh power* of the body's diameter) or by internal radioactivity; instead, according to Edward Stone, Voyager project scientist, its heat source is now thought to be collisions with radiation-belt particles, which are denser around Amalthea than any of Jupiter's other moons. — *Jim Loudon* □

Energy

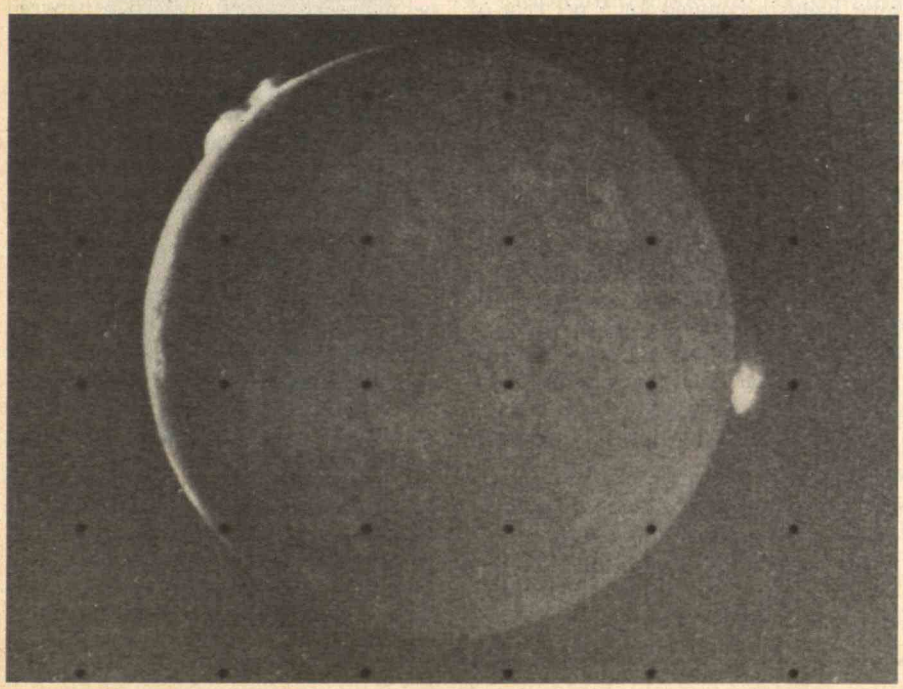
A Gaseous Trend

With regard to carbon dioxide's global buildup, its "greenhouse effect," the consequent warming of the Earth's atmosphere, and the potential inundation of coastal cities, there's some good news and some bad news.

The bad news, according to Gordon J.F. MacDonald, chief scientist at the MITRE Corporation, is that a serious commitment to synthetic fuels could double the atmospheric CO_2 concentration by the year 2010.

The good news, in the words of his colleague Roger Revelle, professor of science and public policy at the University of California at San Diego: "I think Gordon is wrong about that."

Revelle, along with MacDonald and George M. Woodwell of Woods Hole Oceanographic Institution and Charles D. Kelling of the Scripps Institute of Oceanography, warned the president's Council on Environmental Quality in July that atmospheric CO_2 will double by the year 2035 if fossil-fuel consumption continues to grow at its present rate. MacDonald then pointed out that since CO_2 emission from synfuels is 1.4 times that of coal, 1.7 times that of oil, and 2.3 that of natural gas (for equivalent amounts of energy), a substantial synfuels effort by both the U.S. and the Soviet Union (with each producing two to three million barrels per day)



A crescent Io, with its dark side illuminated by a nearly full Jupiter. Huge plumes ejected by volcanoes are visible even from 750,000 miles. The largest plume seen in *Voyager 1* images climbed 200 miles above Io's surface; the heart-shaped pattern made by its ejecta returning to the surface (prominent on page 77, May issue) became elliptically shaped. The plume at the right of this image is 50 per cent larger than in March.

would cause an earlier doubling.

Surprisingly, his was a minority opinion. And a few weeks later, Revelle and three other scientists [Bert Bolin, a meteorologist at the University of Stockholm; Lester Machta of the National Oceanic and Atmospheric Administration; and Stephen H. Schneider of the National Center for Atmospheric Research at Boulder, Colo.] issued a statement for the National Academy of Science's (N.A.S.) Climate Research Board that formally challenged MacDonald's conclusion.

How could Revelle warn of an impending crisis and then discount its earlier occurrence when part of the problem-producing scenario gets even worse? The answer lies in the N.A.S. assumption that the use of synfuels will be limited only to the "next few decades" beyond commercialization — then not to worry.

But would an entrenched synfuels industry — requiring at least a decade and several hundred billion dollars to build — willingly self-destruct as it reached its prime shortly after the turn of the century? And wouldn't a very long-term commitment to coal — whether converted to synfuels or not — bring on the same dilemma within the same time frame?

All this makes solar energy look more attractive than ever. But with relatively low-level and ambiguous federal support at present, who can say when, if ever, it will be a major source of energy?

Meanwhile, in the spirit of getting a lemon and making lemonade: Anyone for a long-term commitment to carbonated beverages? — *S.J.M.* □

Energy: Everyone Now Into the Act

If technology can resolve America's energy problems, then fear not: the job must surely be well in hand.

It was 13 years ago that seven professional engineering and science societies joined to sponsor the first Intersociety Energy Conversion Engineering Conference. Energy conversion technology was a major new opportunity, they reasoned, and it was truly interdisciplinary — for example, mechanical and chemical engineers working together on fuel cells with lots of help from the metallurgists; electrical and automotive engineers turning to chemists for help with batteries for electric cars.

A single 408-page book was adequate for the proceedings of that first conference. Thirteen years later the proceedings — same format — have grown to a prodigious 2,078 pages. No line of attack on energy conversion and exploitation seems unstudied. Some samples from the 1979 conference, held in Boston this summer:

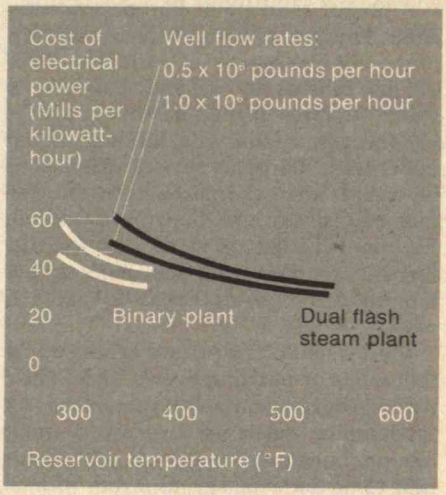
□ If salt is available locally, a solar pond with salty water (to prevent heat loss through convection) is more economic than one with fresh water. But the difference is not enough to justify transporting salt more than a few miles. And the confidence factor in this result is low: "At the present stage of development, solar pond costs can be only roughly estimated." (Michael Edesees *et al.*; Solar Energy Research Institute.)

□ Solar collectors are less efficient in urban than rural areas because city air is so often polluted. The attenuation of sunlight due to tropospheric nitrogen oxides can be expressed as $0.02\ ni/15$, where n = nitrogen oxides in parts per hundred million and i = the thickness of the inversion layer in meters. Similar, if more complex, expressions describe solar attenuation due to stratospheric ozone, tropospheric background dust, fine aerosols, and molecular absorption on water. It's the first unifying method with predictive ability which can take into account the several forms of pollution involved. (Terry R. Galloway, Lawrence Livermore Laboratory.)

□ When small public utilities in the Southeast need more capacity, they may now want to consider adding small solar-thermal power plants instead of conventional oil- or coal-fired boilers. If such solar plants accounted for 5 per cent of total power generation within the next 20 years, the utilities' revenue requirements would be down by 0.88 per cent. (S. A. Bluhm *et al.*; Jet Propulsion Laboratory and Burns and McDonnell Engineering Co., Kansas City.)

□ If you live in Norfolk, Va., and need a new furnace, consider this: a heat pump supplemented by a solar collector (it acts as evaporator for the heat pump) saves you enough money in fuel to pay for itself in 12 years (assuming 8 per cent interest on borrowed capital, fuel costs rising 10 per cent a year, and electric rates maintained at six cents per kilowatt-hour). (S. Chaturvedi, Old Dominion University, Norfolk.)

□ Canada's Defense Research Establishment reports negative results after three years of testing a 15-foot vertical-axis wind turbine at its Ottawa site. Mechanical failures were "frequent," and the wind in Ottawa (annual average, seven miles per hour) could not support the 60-watt load assigned to the turbine. (S. J. Wake *et al.*; Lockheed Missiles and Space Co. — formerly of the Defense Research Establishment.)



Geothermal power efficiency is a function of the temperature of the resource and the well flow rate. With today's technology, only reservoirs in which temperatures are over 400° F can compete with coal and oil (at about 40 to 60 mills per kilowatt-hour) and 500° F with nuclear (at about 30 to 50 mills per kilowatt-hour). The next step is to find new technology to give access to the 120,000 megawatts of potential resources with temperatures between 270° and 400° F.

□ H. J. Heinz Co.'s Pittsburgh factory (baby foods, meat products, canned soups, and canned bean products) discharges down the drains up to 200 gallons per minute of water (temperature between 120° and 170° F) from washers, coolers, and pasteurizers. A system to collect this water and use its heat for preheating fresh water will produce a 42 per cent return on investment by reducing factory fuel consumption. (W. L. Lundberg, Westinghouse Electric Corp., and F. Wojnar, H. J. Heinz Co.)

□ Britain's "milk floats" — door-to-door milk delivery vehicles familiar in major British cities for over 40 years — remain the only long-term, cost-effective electric vehicle fleet in the world. Elsewhere the electric vehicle business awaits the development of a mature supporting infrastructure — as well as some technological breakthroughs such as the improved zinc-nickel-oxide battery claimed this fall by General Motors. (David W. Humphreys *et al.*; Jet Propulsion Laboratory.)

□ This car design would combine it all: an electric motor to power a flywheel for commuting and urban driving, regenerative braking as a source of additional energy to the flywheel, and a 68-horse-

power (1,599-cubic-centimeter) internal combustion engine for long-range highway driving (and to repower the flywheel if the driver gets caught with his batteries down). The car would weigh 2,850 pounds, travel 24 miles on a gallon of gasoline or use 11.45 kilowatts of electricity an hour (if electricity costs five cents per kilowatt-hour, that's two cents a mile). (T. Volz *et al.*; College of Engineering, University of Wisconsin.)

☐ Or perhaps you prefer a fuel cell in your next car, because as heat engines fuel cells are efficient and nonpolluting. A 15-kilowatt fuel cell, 4 kilowatt-hours of batteries, and an electric motor could be squeezed under the hood of a Volkswagen Rabbit, which would then weigh 622 pounds more than today's stock version. But buses and heavy duty trucks may be more practical applications because of fuel cells' long lifetimes (up to 40,000 hours) and economy. (Byron McCormick *et al*; Los Alamos Scientific Laboratory).

☐ Zinc chloride batteries may be ready for use in electric vehicles in the 1980s, a 50-kilowatt-hour unit costing $1,640 (1977 dollars). It would give a 50-mile range to a 3/4-ton-capacity truck whose curb weight (including batteries) would be just over 2,000 pounds. To give the same truck a 150-mile range would require $3,400 — and nearly 1,000 pounds — worth of batteries. (C. H. Chi *et al.*; Energy Development Associates.)

☐ "Very encouraging" results in field testing of underground (*in situ*) gasification of western coal. In 55 days, an average of 8.5 million cubic feet per day of low-B.t.u. gas (165 B.t.u.s per cubic foot) was produced with air gasification; and at another western site 1.7 million cubic feet a day for 58 days of medium-B.t.u. gas (263 B.t.u.s per cubic foot) with steam/oxygen gasification. (Douglas R. Stephens, Lawrence Livermore Laboratory, *et al.*)

☐ Where the geothermal reservoir is hot enough (at least 400° F) and productive enough, geothermal power is expanding "exponentially" — about 19 per cent per year in the U.S. But identified 400° F geothermal resources in the U.S. could provide less than 16,000 megawatts of capacity for only 30 years. What's needed is new technology to make possible development of the 120,000 megawatts available from geothermal resources with temperatures from 270° to 400° F. (T. W. Lawford, E G & G Idaho, Inc.)

☐ Department of Defense spacecraft now require 0.5 to 10 kilowatts of electric power, obtained chiefly from solar arrays. But future needs will range up to 50 kilowatts (a large radar in synchronous orbit, for example), and small nuclear power plants are among the options being considered. Whatever system is finally chosen will have to be "hardened" to survive "an enhanced threat environment" predicted for military satellites. (R. R. Barthelemy, Wright-Patterson Air Force Base.)

☐ The same problem is now anticipated on civilian space missions — a proposed holographic teleconferencing mission

would need over 200 kilowatts of power, for example. Nuclear power may turn out to be indispensable. There's "a high degree of confidence" that "technical feasibility" can be demonstrated for a 100-kilowatt nuclear power plant which would weigh in at just under 1,500 kilograms, and the risks involved would be "reasonable." (David Burden, Los Alamos Scientific Laboratory.)

☐ A pessimistic report on cogeneration — the use of waste heat from industrial processes for generating electricity which then is returned to the grid. Power produced could readily be accepted, and plenty of equipment is available. But the minimum practical cogeneration facility is about five megawatts (100,000 pounds of steam per hour), and almost every boiler of this capacity now in service would have to be extensively modified or replace. (T. E. Root, Detroit Edison Co.)

☐ By 2025, when its oil is depleted, Iran could still find itself energy self-sufficient; renewable resources — solar, wind, and biomass — could be ample, even assuming only today's technology. Solar would be used for heat, biomass for liquid fuels, and wind for electricity. Two major constraints: lack of water to irrigate biomass crops and the need for nearly 5 per cent of Iran's total land area for windmill sites. In addition, there are "formidable social and institutional problems" to be overcome. (M. Sanai, Teheran University of Technology.) — *J.M.* ☐

An Energy Strategy for World Partners

If the industrial nations accept an obligation to help achieve a just and sustainable world, what strategy should they adopt to meet their energy needs for the next two decades?

Turn as quickly and as fully as possible to nuclear and solar power, says David J. Rose, professor of nuclear engineering at M.I.T.

His thinking, outlined before the World Council of Churches' Conference on Faith, Science, and the Future at M.I.T. last summer:

☐ Oil and natural gas are the fuels of choice for developing countries; they are "the natural fuels of intermediate technology," easy to handle and relatively easy to burn. The world's limited supplies should be conserved for them — at prices they can afford.

☐ There is the real possibility of a global "CO_2 crisis" — an irreversible increase in the carbon dioxide content of the atmosphere causing serious climatic change — if the industrial nations turn heavily to coal. (A given quantity of energy produced from coal results in 60 per cent more CO_2 than the same amount of energy from oil or gas.)

☐ The industrial nations are the only ones that can capitalize on high-technology nuclear power and at the same time create the technology necessary for large-scale, efficient solar utilization. If they don't do it, no one will.

In addition to these advantages, Professor Rose thinks such a strategy, in which the industrial nations deliberately chart a course that serves the interests of the third world, would do a lot toward "making the developing countries full partners in the global enterprise of managing global affairs."

"People in many developing countries," said Professor Rose to the W.C.C., "see themselves as standing at the side of a railroad track, watching the train of the industrialized nations going by at ever-increasing speed. . . . Their only possibility to gain anything is to derail the train." — *J.M.* ☐

Computers

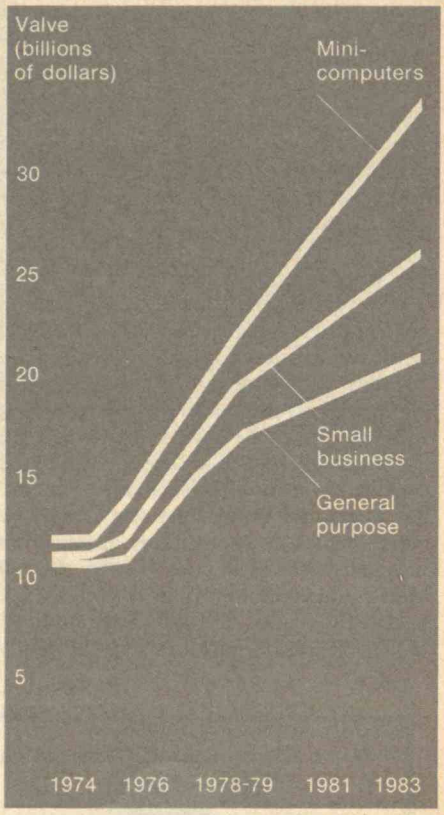
Putting Up the Chips in the World's Fastest Industry

It's hardly news that computers are growing ever smaller, more powerful, and more important in our lives.

Most of us attribute these trends to the success of miniaturization: more and more powerful circuits that handle incredibly complex functions can be put in ever-smaller volumes at lower and lower prices.

But that's not the only reason. Increasing numbers of users turn out to be disenchanted with massive, general-purpose mainframe systems.

Surveying business leaders who want computers to help with day-to-day strategic decisions, John F. Rockart, senior lecturer in M.I.T.'s Sloan School of Management, finds a good deal of impatience — and notable unamimity on it. Executives want information faster than they can now have it; they want to ask their computers for what they need instead of receiving periodically the data which a systems planner thought they might need; they are frustrated by the large backlog of programming; and they are upset by the high cost of the human support required by computers — over the space of a year, perhaps ten times the cost of the machine itself.



Values of U.S. computer-maker shipments, projected to 1983. Paradoxically, the computer business is going from big to small — users are opting for the greater flexibility and quicker response that can be had by substituting dedicated small computers for general-purpose big ones. The trend will continue for at least the next five years, according to C. Oakley Mertz, vice president for research of International Data Corp.

So management is turning away from centralized systems to minicomputers, even microcomputers, which can be located where they're needed — even imbedded within other machines — to do the special jobs that need to be done.

All this tends to make the computer industry a rough-and-tumble, high-risk arena. But it's not exactly suffering. Total U.S. computer shipment revenues will be up 11 per cent in 1979, and "double-digit" growth will continue at least through the mid-1980s — a "recession-resistant industry," says Patrick J. McGovern, chairman of International Data Group. For reasons made clear by Dr. Rockart, who spoke at a small-

business-computers symposium sponsored by I.D.G.'s International Information Technology Institute late last spring, small business computers are one of the hot spots in this hot industry. Sales in this category were up 35 per cent last year, and they will triple — to $10 billion a year — by 1984, according to I.D.G. figures.

If the makers' claims are true, this prodigious outpouring of hardware and software will mean more efficient management of countless enterprises — even down to those employing no more than 25 people. But what does that really mean? Participants in the Boston conference were given a list of prognostications and asked to put dates on the ones they liked and cross out the ones they thought too far out.

Nothing was crossed out, according to Mr. McGovern; so presumably nothing lay beyond the conferees' imaginations. Among the predictions:

☐ By 1990, most bills will be paid by electronic funds transfer initiated by an electronic terminal in the home.

☐ By 1990, it will be normal for businesses to provide terminals accessing data-and word-processing systems to employees who want to work at home.

☐ By 1988 typewriters will be obsolete unless they have storage, text editing, and data-transmission capabilities.

☐ By 1990, all computers will be programmed in conventional English; specialized programming languages will not be needed. ("Putting users even closer to the headaches," muttered one respondent.)

☐ By 1990, compliance with government privacy regulations will account for half the cost of maintaining data bases.

☐ By 1988, speech recognition will become a significant form of data entry.

☐ By 2000, the computer industry will become the world's largest in terms of total revenue. (A "prediction" that simply extrapolates for 20 more years the industry's current 12 per cent annual growth rate.)

Readers tempted to take these predictions too seriously are referred to the advice of Edson de Castro, president of Data General Corp., who says talk about the future of information systems makes him "paranoiac. . . . The record of technologists in seeing their future is worse than economists' ability to see into theirs and probably on a par with political pollsters' skills in calling elections," he told a computer symposium of the M.I.T. Alumni Center of New York late last year. —*J.M.* ☐

Computers and Education

Computer technology has become so inexpensive — and computers themselves so small that "the computer can now become a part of a child's personal life," says Seymour Papert of the M.I.T. Division for Study and Research in Education. And when each child has a personal, portable computer, parents and educators will have to think in new ways about schools and education. Schools as they are now are already obsolete, Papert told a computers-in-education seminar at M.I.T. this spring.

His colleague John Holt, author of *How Children Fail*, agreed: in the classroom, he said, children must conform to behavior patterns and engage in activities that may make little sense to them. They come away from the classroom feeling powerless and alienated.

Under these circumstances children do not learn. Ironically, teaching — the main activity of the classroom — "impedes learning and gets in the way (and takes the place of) those motivations that are the root of learning," said Dr. Holt.

Can the computer change this? Compare the computer to the pencil, said Dr. Papert, and its potential becomes clear. The child controls the computer just as he controls the pencil. But the pencil limits the child who, for example, is learning composition. Correcting mistakes, changing words and phrases, and moving sentences or whole paragraphs are messy and hard to do with a pencil. The computer makes these things easy to do. Learning proceeds more smoothly, since the child is not so likely to become frustrated.

And childrens' use of a computer is not limited to writing. A child can program the computer to draw, make music, aid in science and history projects, and play games. "The computer expands a child's field for action," according to Dr. Papert.

Here is Dr. Papert's scenario for a child using a computer: the child is given free reign to accomplish a project of his own

choosing; he is expected to program the computer to do what he wants it to do. For example, if the child wants to draw a square he does this by telling the computer to move forward a certain amount, turn a certain amount, move forward the same amount as before, turn again and so on. The child learns about angles and other geometrical concepts in a way that makes them alive and real to him. "The child learns by doing," says Dr. Papert.

Will the computer used as such a powerful learning tool replace the classroom so that children will learn at home in the 21st century? Or will the computer, as an automated teaching aid, become part of the classroom? Even the experts don't know. "It could make present classroom and teaching methods more rigid or it could make them more open," says Dr. Papert. — *Steven Frann* □

Moving

Maneuvering Into a Crash

The two ships among the words in the heading are perhaps five miles apart, proceeding at normal throttle. Each sees the other by radar, and each could talk to the other by radio. If they maintained course they would be perhaps a mile apart as they passed.

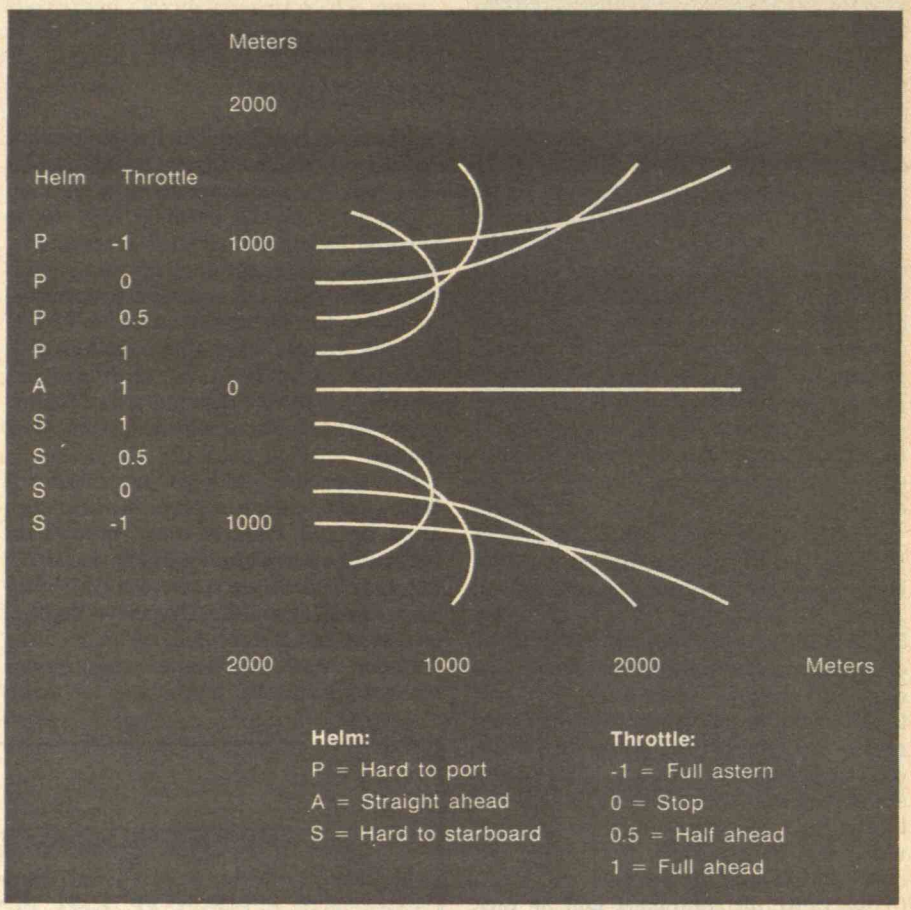
But it is a dark, foggy night. They enter into a "dance of death" and collide.

This scenario was enacted by the *Andrea Doria* and *Stockholm* off Nantucket in August, 1956, by the *Horta Barbossa* and *Sea Star* (resulting in one of the largest oil spills on record) in the Gulf of Oman in 1971, and in at least ten other end-on encounters on the high seas in the last 15 years.

What happened?

The "Rules of the Road" require port-to-port passing (that is, each ship to keep the other to its left) if there appears to be danger of collision. But ambivalence remains: if one captain elects a port-to-port passing and the other does not, a collision course is almost assured; and as they approach, both will have the false confidence of seeing constant change in their relative bearings.

Furthermore, both Rules of the Road and judges in marine loss cases suggest that captains reduce speed if collision danger exists. But if either reduces speed, he inevitably reduces his ship's maneuverability and hence his chances of avoiding a collision at the last minute.



Ship maneuverability as a function of speed. Tests with the *Esso Bernicia* show the fallacy of reducing speed when a collision between two ships is feared. Indeed, write John W. Devanney, S. Protopapa, and Rolf Klock in an M.I.T. Sea Grant report, "large ships, especially large tankers, will not only turn much more sharply but will also slow down more quickly if the throttle is advanced rather than retarded during the maneuver."

This analysis is part of a study of marine tanker oil spills, collisions, and groundings by Professor John W. Devanney and Rolf Klock of M.I.T. and S. Protopapa of the U.S. Department of Transportation's Systems Center in Cambridge. Reasoning that tanker traffic in U.S. waters can only increase in the future (their estimate is from just over 10,000 ships in 1974 to at least 20,000 in 1984), the three analysts set out to identify common causes of accidents and then to propose solutions.

Most groundings in U.S. waters have occurred near ports, they found. The *Argo Merchant* scenario — a grounding in mid-route, well offshore, due to navigational error — is "an extremely unusual casualty," they say. Two locations have especially bad records: the entrance to Delaware Bay and the entrance and waters of Guayanilla Bay on the south coast of Puerto Rico. Fully-laden tankers entering port are more likely to ground than empty ones leaving. Most groundings occur at night, but many occur under conditions of good (night-time) visibility. And ships appear to be especially vulnerable while maneuvering to pick up or put off pilots.

On the basis of this analysis, Messrs. Devanney, Protopapa, and Klock urge careful surveys of currents, bottom profiles, and aids to navigation (and perhaps dredging) in Delaware and Guayanilla Bays. And they recommend a clearance system for tankers entering U.S. waters modelled after a Canadian system that permits the denial of territorial waters to ships with poor operating records or current deficiencies.

To eliminate the conditions which seem so inexplicably to lead to collisions, the Rules of the Road should be changed to eliminate ambiguities. But most of all, ship captains should turn to ship-to-ship

radio communications, now almost wholly neglected by colliding ships even *in extremis*. Messrs. Devanney, Protopapa, and Klock dismiss the reasons usually given for captains' reticence to try to talk to each other: the lack of standardized equipment (it is inexpensive), the language barriers (only a small vocabulary is required), and the problems of identifying the speaker and perhaps of channel saturation when several ships are present in the area (some simple form of transponder capability may be needed). — *J.M.* □

Fast Surfing Down a Magnetic Wave

How to give a projectile a vast amount of kinetic energy — speed — very quickly? The object of the problem is commonly a bullet, and the usual answer is gunpowder — a form of chemical propulsion.

But the future belongs to electromagnetic propulsion achieved in a "mass driver," says Henry Kolm of the Francis Bitter National Magnet Laboratory at M.I.T.

It works this way, he said in a paper for the Intersociety Energy Conversion Engineering Conference in Boston last fall: A reusable "bucket" is suspended by onboard magnets in a U-shaped guideway. The payload sits inside the bucket. Coils built into the guideway can be pulsed to repel the bucket; if the pulses are properly synchronized, the bucket can be accelerated down the guideway to very high speeds — "like a surfboard riding the forward crest of a magnetic traveling wave," Dr. Kolm said.

Given an efficient guideway and the right pulse-generating equipment, a bucket could be launched from such a mass driver every second. Theoretically, there are no limits to the length of the guideway or the velocity of projectiles launched from it. "Mass Driver Two," now under construction at M.I.T. and Princeton, uses only on-the-shelf components; it should achieve acceleration of 500 to 1,000 times that of gravity. The ultimate limit, set by the capacity of the drive coils, may be as high as 100,000 to 250,000 times the acceleration of gravity. Energy efficiency — that is, the ratio of the energy given the bucket and its payload to that originally supplied to the coils — is at least 90 per cent.

Now Dr. Kolm and his colleagues are working on a special case of the "mass driver" which they call a "momentum transformer." Coil windings are added to the barrel of a conventional gun, and they're pulsed in such a way that the projectile receives boosts from the coils and from a magnetic flux in the barrel itself. Installed in a 105-millimeter gun, a momentum transformer may more than double the muzzle velocity of a one-kilogram shell.

Other applications for mass drivers: to launch aircraft and space vechicles, to provide pellets for hypervelocity (10 to 100 kilometers per second) research and to send military supplies to front-line fighters. "It is an irony of modern tactical warfare that an armored advance can be supported with many tons per minute of artillery but not by a single gallon of fuel or pound of food," says Dr. Kolm.

"The widespread use of pulsed electric power for propulsion appears to be as inevitable as any technology whose time is ripe, from the wheel to the wing," Dr. Kolm prophesies. — *J.M.* □

Innovation

Why Innovation Fails Our Cities and Schools

"If we can go to the moon, why can't we fix up our cities?"

Countless models, analyses, and policy studies have been spawned in that lament. But the frustrations in which it is born have not lessened: while Concorde flies the world, the Space Shuttle nears launch, and *Voyager* streaks toward Saturn, such targets as cities, schools, and the health care and housing industries still seem to blunt every innovative engineer's thrust.

Why has innovative technology had so little impact on these public needs? In a word: because no one knows how to supply it, said a dozen experts attending a workshop on the introduction and management of innovative technology sponsored by M.I.T.'s Technology and Policy Program early this year.

The ability to specifically define intent seems to be crucial — "an enormous advantage in the management of innovation," said Dean Gillette of Bell Telephone Laboratories, Inc. For example, consider a communications systems such as the telephone network: its primary goal is easy to define — to make fast, dependable, and inexpensive connections between people or machines who want to talk to each other. Measures of how well the system works are inherent in its management, and it's relatively easy to maintain the focus of research on real goals, to organize and build the base of information that's

needed, and to bring research results to those who can use them.

"For comparison," Mr. Gillette said after reciting this list of advantages, "think of trying to be so specific about what should be meant by 'improving education' or 'better delivery of health care.' "

Consider the would-be educational innovator seeking the object of his study. "All school settings are in some measure unique," said Ronald G. Havelock, director of the Knowledge Transfer Institute at American University, and — even more important — "all perceive themselves as unique." Each tends to embrace improvements that are self-initiated and self-directed. The result: innovative change in education has as many different meanings as there are teachers in countless different classrooms — and students.

Or consider the innovator with a new renewable energy resource. Critical information is lacking because there is no organized market for the product — no way of relating it to needs and costs, supply and demand. "Selecting technologies is made virtually impossible without a clear description of objectives and a rank order of the goals," said John Ashworth of the Solar Energy Research Institute.

In the case of medical technology, the ultimate stimulus is unmet clinical need, said Richard A. Rettig of Rand Corp. That seems specific enough, until you consider the number of actors in the play: hundreds of patients and doctors widely dispersed among countless hospitals, public and private. Each patient is an individual with unique problems and preconceptions; each doctor is an individual entrepreneur who's accustomed to setting personal priorities and making independent decisions.

The difficulties for entrepreneurs who would serve the public sector have some "Catch-22" characteristics. Listen to Professor W. Henry Lambright of the Maxwell School, Syracuse University: "The fragmentation of local governmental authority requires coalition-building. To build coalitions requires change in the technology and in the city and its institutions. Since change is difficult and often resisted, the local entrepreneur invariably faces a formidable challenge. . . . Unless there is a spirit and reality of entrepreneurship, a push for innovation from outside leads nowhere." — *J.M.* □

Managing

Vive la Différence in R&D Managers

It's axiomatic that good communications are an essential part of the environment for productive research and development; but that axiom grossly oversimplifies real life. As he begins to see some details of the communication process in research and development laboratories, Professor Thomas J. Allen of the Sloan School of Management at M.I.T. thinks his results hint at fundamental differences between the way different research and development functions operate and the ways they should be managed, he says — a "fruitful new area for research."

Before he began these newest studies, Professor Allen had helped establish the idea that researchers' needs for communication depend on whether their responsibilities are in research, development, or technical service. In the new research, he and his colleagues have begun to analyze some details of these different communication needs. For example, how does the nature of the task and the background of the individual worker affect the need and mechanism for communications with different groups of colleagues?

Considering communications with fellow project members and laboratory colleagues, the answer is: very little. And there is essentially no relationship between the amount of internal communication and the quality of project performance.

But considering communication with parts of the firm outside of the research and development laboratory, the answer is very different: the average research worker communicates with his colleagues outside R & D less frequently than does the average engineer in development and far less frequently than the engineer in technical service. Technical service benefits from good ties with marketing and — to a lesser extent — with manufacturing. Development *must* have strong connections with both marketing and production — "a result than cannot be overemphasized," write Professor Allen and two colleagues, Denis M.S. Lee and Michael L. Tushman.

The technical manager's role as communicator varies, too. In research, it's apparently important for each member of a project to participate equally in intra-project communication. The opposite seems to be true for technical service, where the technical manager should take a strong role. In external communications, the manager should have no special role; all engineers and scientists should share the experiences and opportunities of communication.

Clearly, write Professor Allen and his colleagues, "not all research and development functions are alike in the way they operate," and each may well benefit from its own style of management. — *J.M.* □

Planners Without Plans

Everyone wants a plan for the future based on a model of the past: the president and Congress want an energy plan, the chief executive officer of every major corporation wants a marketing plan and the chairman of its board wants a long-range plan. Planning is the "in" tool of management everywhere.

But models for their planning process are the last thing the planners want, and therein lies their biggest problem, says Ben C. Ball, Jr., adjunct professor of management and engineering at M.I.T., writing in the *European Journal of Operational Research*.

Professor Ball distinguishes between modeling and planning this way: it's the business of modelers to show how the world worked in the past and has changed into the present. The planners' job is to use this information to foresee the future. Simple enough.

But an essential link is missing, says Professor Ball. To make a planner angry, all you have to do is ask him about his five-year plan for his planning process. You'll soon enough discover that the planner lacks a model for his planning, and he doesn't want one: "He's too busy planning," explains Professor Ball.

What's needed is "strategic planning for what modeling can do for the planning process." — *J.M.* □

Antarctica: How Pure Should Pure Be?

Antarctica is the last pristine continent on earth — 5.5 million square miles, two-thirds again as large as the U.S. Given this fact, there are two ways of looking at the environmental impact of the 1,000 U.S. scientists and support personnel who are on the continent every summer and the 100 who remain for the long Antarctic winter:

☐ Because the environment has been so little affected by man, each environmental insult is a major one.

☐ Because the continent is so large and its population so small, pollution can continue for many years before it even begins to approach levels long since proved safe on other continents.

The second view appeals not at all to James N. Barnes, an attorney with the Center for Law and Social Policy in Washington, D.C. Speaking to the American Institute of Chemical Engineers in Boston last summer, he sounded a strong warning: present hypotheses suggest major mineral resources — both oil and ores — on the Antarctic continent. Exploitation of these — or even commercial exploration for them — could cause "severe and virtually irreversible" effects on the fragile Antarctic ecosystem.

He called for a moratorium on mineral exploration and expanded research on:

☐ The primary marine, aquatic, and terrestrial ecosystems on the continent.

☐ The key organisms in each ecosystem.

☐ The areas of Antarctica most vulnerable to ecological impacts.

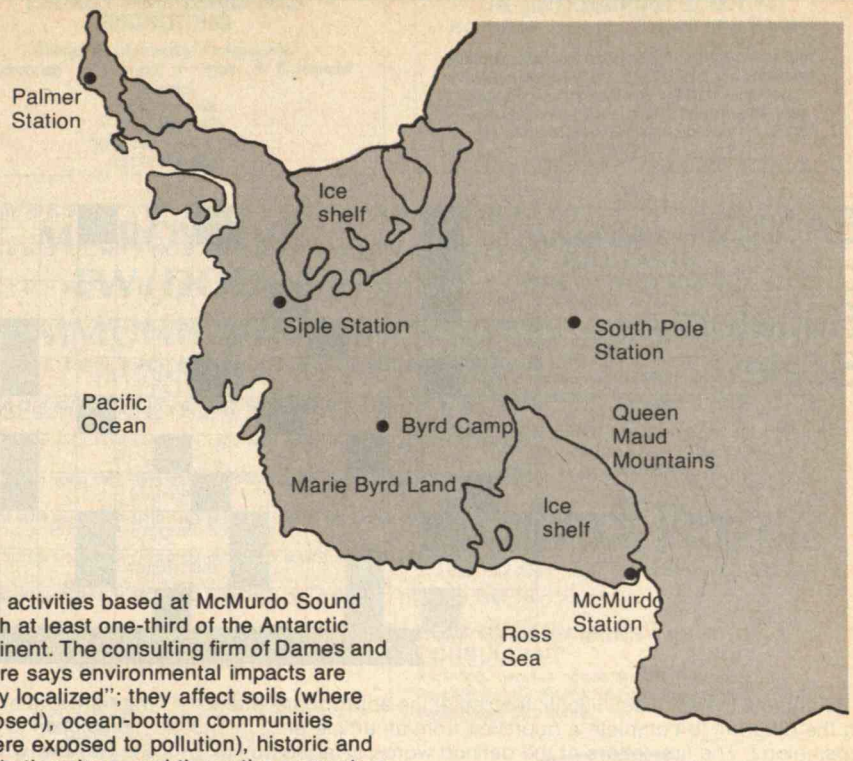
☐ The areas of Antarctica where minerals are most likely to be found.

But what will be the effects of such a major research effort?

Already U.S. Antarctic research, under the management of the National Science Foundation, has impacted the continent more than minimally, according to Roger F. Hatcher, Richard C. Tucker, and Natalie S. Waugh (with Charles E. Myers of the N.S.F.) reporting to the A.I.Ch.E. last summer in Boston.

The U.S. brings 5 million gallons of petroleum products to Antarctica every year. There are "frequent" small spills, but their impact is generally not significant. Because the southern ocean is so large, even a relatively large oil spill at sea "is not likely to have catastrophic effects on the marine ecosystem as a whole." But there could be severe local effects, penguins being especially vulnerable.

Solid wastes are mostly burned, with the residue buried in soil or (at the South Pole and Siple Stations) in ice holes. But burning adds pollutants to the air, soil, and water, which in general are unpolluted; and leachates from the dumps may find their way into the sea. Some oceanic life-forms will be poisoned; some will thrive on the new materials; and — because the food chain is very short in Antarctica — metallic wastes could concentrate quickly in the higher animals — penguins and other birds, seals, and whales.



U.S. activities based at McMurdo Sound touch at least one-third of the Antarctic continent. The consulting firm of Dames and Moore says environmental impacts are "very localized"; they affect soils (where exposed), ocean-bottom communities (where exposed to pollution), historic and aesthetic values, and the entire ecosystem (through very-low-level contamination).

Human wastes are generally dumped in the sea, or the ice, without treatment. Thus, a whole community of foreign organisms is released to the environment; they're unlikely to grow or reproduce, but they may remain viable. And where solids settle to the bottom of the sea, there are changes in the benthic population.

Radioisotopes are important tools in Antarctic research, and their use has led to radioactive concentrations "far above background levels" the scientists told the A.I.Ch.E. "Already . . . Lake Vanda, one of the largest dry valley lakes in South Victoria Land, may contain enough carbon-14 left by prior investigations so that carbon dating of its waters is not possible."

People themselves are a foreign life form in Antarctica. They inevitably bring with them bacteria, fungi, and viruses. Their goods — food, vehicles, and the like — bring seeds and spores of higher forms of life which are equally foreign. Though most of these cannot reproduce in Antarctica's stern environment, many are preserved by freeze-drying to become a new part of Antarctic biota. What then?

Humans collect things wherever they go, and scientists in Antarctica are no exception: rocks, ice cores, fossils, soil samples, meteorites, and biota have all been brought back to U.S. laboratories for detailed study. How much is too much? The Dames and Moore study notes that the richness of the fossil record on the 2 per cent of Antarctica which is ice-free has already been reduced, and some future generation of scientists may well discover that evidence it seeks is no longer available. Removing seals may affect the future of the species: seals first breed between three and seven years of age, and they have but one pup every other year — a "fairly low reproduction rate."

Dames and Moore identified four "significant" environmental impacts:

☐ Alteration of soils — they are unique, the results of very slow geological processes — from ice-free areas.

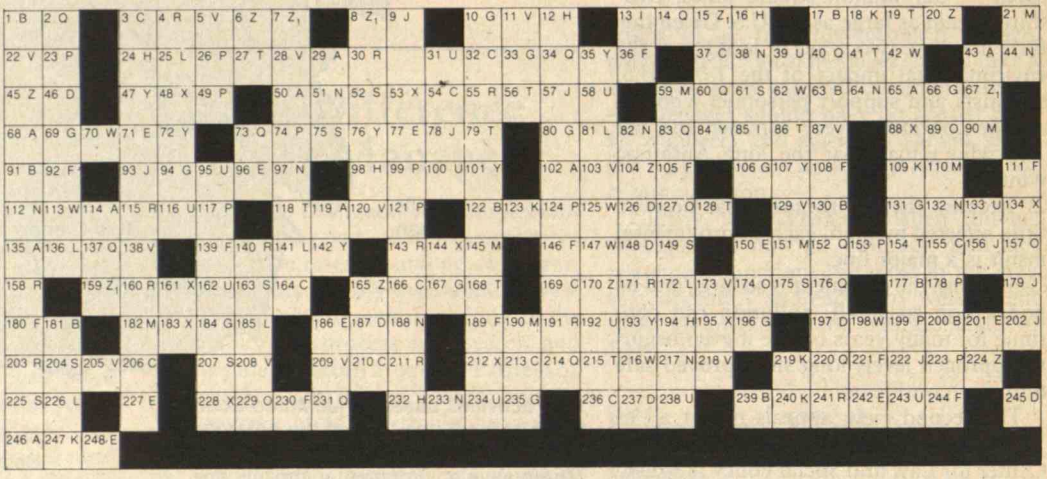
☐ General contamination, which jeopardizes use of Antarctica as a "global benchmark for pollution."

☐ "Continuing change in the population dynamics" of the ocean bottom due to sanitary waste disposal at McMurdo.

☐ Degradation of aesthetic and historic values near McMurdo. Dames and Moore complained of "vandalism and souvenir hunting" in the historic buildings and of waste handling facilities and their products.

Withdrawal from the continent — or even a decreased presence there — is not a feasible U.S. response, said the Dames and Moore analysts. But N.S.F. has pledged that "any major increases in the U.S. program" will be undertaken only "after a careful assessment of the benefits . . . compared to the increased . . . environmental impacts." — *J.M.* ☐

Energy on a Subatomic Scale



Complete the word definitions; then enter the appropriate letters in the diagram to complete a quotation from an article on cosmology. The first letters of the defined words give the author and title from which the quotation is taken. Black squares in the diagram indicate the ends of words; if there is no black square at the right end of the diagram, the word continues on the next line.

A solution to this Tech-Crostic will be given in the next issue of the Review, when another of Mr. Forsberg's puzzles will also appear. Readers are invited to comment — and to suggest favorite texts for future puzzles.

A. Comedy of 411 B.C.
65 135 29 119 50 68 43 114 102 246

B. Character in Thomas Mann's *Dr. Faustus*
200 130 177 239 63 17 122 181 1 91

C. Louisiana town on the Red River
32 166 54 37 236 213 206 169 164 210 155 3

D. Mange
46 126 187 245 237 197 148

E. American liner, launched as the *Vaterland*
248 150 201 71 227 77 186 96 242

F. Supported by charity
221 139 111 189 146 92 244 36 108 180 230 105

G. Variant name of English village, Roman *Lindinae*
167 80 184 131 235 106 69 33 196 10 66 94

H. First producer of steel in America
24 12 232 194 98 16

I. Result of legendary attempt to condense the world's knowledge into one word
85 13

J. Communication medium revolutionized by the spraycan
93 222 202 9 179 78 156 57

K. German dramatist, 1813-1863
18 219 123 109 240 247

L. Turkisk title of respect
185 226 141 172 81 136 25

M. Potion inducing oblivion
190 90 59 145 151 21 182 110

N. Used language deceptively or ambiguously
233 112 51 217 132 38 64 44 97 82 188

O. Metal fastener
89 157 174 229 127

P. Premier of Rumania, 1952-55 (comp.)
223 99 23 178 153 26 121 74 199 117 49 124

Q. Short story by Saki (two words after "The")
231 14 83 73 60 220 176 40 137 214 2 152 34

R. Pastry used as refrain by Winnie-the-Pooh (two words)
158 160 143 30 203 191 171 115 55 241 4 140 211

S. Ohio college, founded 1847
225 149 207 175 61 52 204 163 75

T. Describing "Frau" in Straus opera
168 79 27 118 86 41 154 128 19 56 215

U. Famous sea mystery, 1872 (two words)
162 100 192 243 31 58 133 234 116 39 238 95

V. Order of extinct birds
129 218 103 209 22 138 208 173 205 5 120 11 28 87

W. A flirt
42 147 198 113 70 62 216 125

X. Character in Arthur C. Clark's *Childhood's End*
48 53 161 144 183 228 195 134 88 212

Y. Mechanically separable mineral mixture
47 35 84 72 76 193 107 101 142

Z. Swedish town immortalized in the Periodic Table
224 20 6 104 165 170 45

Z_1. Describing painting on dry plaster (Ital.)
67 7 159 15 8

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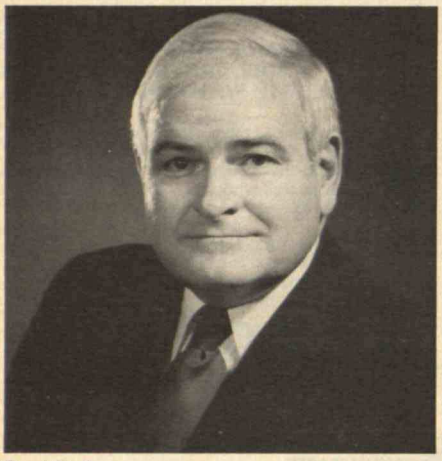


Paul E. Gray

An M.I.T.-Produced Engineer Tapped to be Its President

Paul E. Gray, who as chancellor has been the Institute's second highest officer since 1971, will succeed Jerome B. Wiesner as president of M.I.T. on July 1, 1980.

Dr. Gray has been at M.I.T. almost continuously since he entered the Institute as a freshman intent on studying electrical engineering in 1950. There were two years of military service after receiving his master's degree in 1955, but by 1957 he was back as a teaching assistant and graduate student in semiconductor electronics and circuit theory, the fields in which he received his Sc.D. in 1960.

Thereafter he advanced through the ranks of the M.I.T. faculty to become full professor in 1967 while gradually assuming more administrative duties.

Dr. Gray shares with many of his colleagues an active interest in the relationship between engineering and the society it serves.

"While it is true that technological activity and the rate of societal change to which it is intimately coupled have produced major problems for our society," he has written, "these problems are trivial compared to those that would arise were we now to turn our back on technology.

"What is needed is a concerted effort on the part of both engineers and those whose needs they serve to explore the consequences of technologically-induced change and to foster wise and timely choice among fully developed alternatives.

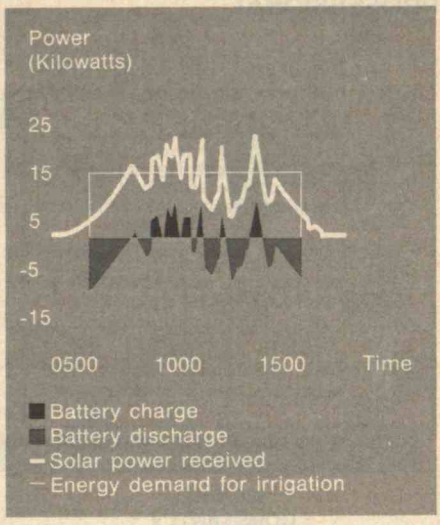
"I believe, and I certainly hope," he said, "that people everywhere thus associate M.I.T. not only with science but with science in the service of humanity."

Solar Irrigation Passes a One-Year Test

Two years ago engineers from M.I.T. Lincoln Laboratory and the University of Nebraska joined to design a solar (photovoltaic) system for pumping irrigation water at the university's Agricultural Research Station in Mead, Neb.

Now, on the basis of the system's performance during the 1978 irrigation season, its designers pronounce it a success.

During the heart of the 1978 irrigation season, in August and September, the photovoltaic array produced all the power required for irrigation — a total of 3,400 kilowatt hours. The back-up connection to commercial power was never called on. Indeed, during the period some 10 per cent of the power from the solar system was surplus, dumped as waste heat, according to the report by L. L. Bucciarelli and R. F. Hopkinson of Lincoln Laboratory to the Intersociety Energy Conversion Engineering Conference in Boston late last summer. In a little more than a year the output of the photovoltaic arrays had dropped about 10 per cent — not unexpected — due to dirt accumulation and deterioration of the individual silicon cells. □



A typical day (August 8, 1978) of solar-powered irrigation at the University of Nebraska's Agricultural Research Station. Irrigation pumps are turned on at 7 a.m., long before significant solar power is available; at first the inverter powering the pumps draws most of its energy from the battery system. As sunlight increases, photovoltaic power approaches and — just before 10 o'clock — exceeds that required by the inverter, leaving surplus power to be returned to the batteries. Solar output, battery storage, and battery drain vary during the day as broken clouds interrupt the sunlight to the photovoltaic arrays; but on this day, as it was on average throughout the 1978 irrigation season, the total power from the photovoltaic system was adequate to cover pumping irrigation water for 80 acres of corn.

Running Up Television

You look contemptuously through your neighbor's window to see the television set on every evening? Look at yourself instead, says Professor David Thorburn of the M.I.T. Department of Humanities.

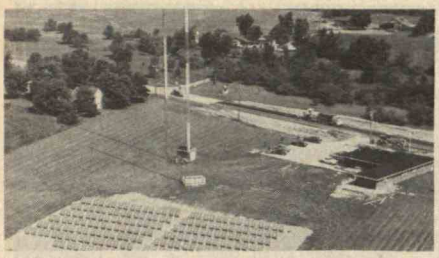
"Could it be that the pervasive contempt with which most educated people claim to regard television . . . is a secret, unacknowledged form of class warfare, an assault on that vast majority of our neighbors and fellow citizens who watch television without guilt?" he asks.

Professor Thorburn admits that he finds "much that is banal and vulgar and even morally offensive on television." But his set also brings him "enormous pleasure, complex aesthetic and intellectual satisfaction," he says. "We impoverish ourselves and demean our neighbors and our society by refusing to recognize . . . how often our television succeeds, how regularly and even brilliantly it offers . . . skill, intelligence, and artistic passion." □

Bringing Citizens and Government Together

How can citizen participation be more effectively used to resolve disputes between local governments and those they serve in the U.S.?

Seeking an answer, the German Marshall Fund of the U.S. has given the M.I.T. Department of Urban Studies and Planning a $70,000 grant to review citizen participation programs in Europe. A team of experts assembled by M.I.T. will study innovative citizen participation efforts in several European countries; findings will be reported early in 1980 at a conference for members of the National League of Cities, National Municipal League, U.S. Conference of Mayors, and the International City Managers Association. □



A photovoltaic radio station. WBNO (AM) of Bryan, Ohio, now uses solar energy for almost all of the power needed for broadcasting. The array in the foreground contains 33,600 photovoltaic cells which generate a maximum of 15,000 watts; solar-charged batteries power the load on cloudy days, and a connection to the local utility provides a back-up.

Solar Power on the Air

For most of its on-air time since August 29, station WBNO (AM) of Bryan, Ohio, has operated on solar power. An 800-module solar array containing 33,600 photovoltaic cells has provided 15,000 watts peak power capacity, and batteries have been available on cloudy days. The commercial power connection that previously gave the station all its energy has been used (only occasionally) for back-up service. Surplus power — beyond that needed to maintain the batteries' charge — has sometimes been available for studio, newsroom, and production rooms.

The project is part of the U.S. Department of Energy's program to bring solar cells into widespread use in the 1980s. Under a D.O.E. contract, M.I.T. Lincoln Laboratory designed the WNBO system, helped install it, and will join the station in monitoring results over several years.

Marvin D. Pope, manager of Lincoln's photovoltaic project, says a daytime radio station is "an excellent application" for a photovoltaic system. The load is predictable, and it generally peaks during the hours when solar energy is most readily available. Mr. Pope admits that in the short run the cost of solar-generated electricity is still higher than that from conventional utility sources. But the gap is narrowing as the price of fuel goes up and of solar cells goes down; and he thinks the experience from projects such as this will soon enough be in demand.

Meanwhile, Mr. Pope and his colleagues are continuing design of the world's largest photovoltaic installation — a 100-kilowatt system which will silence several diesel generators by providing all the power needed by Natural Bridges National Monument, Utah. □

Boulding

Continued from p. 8

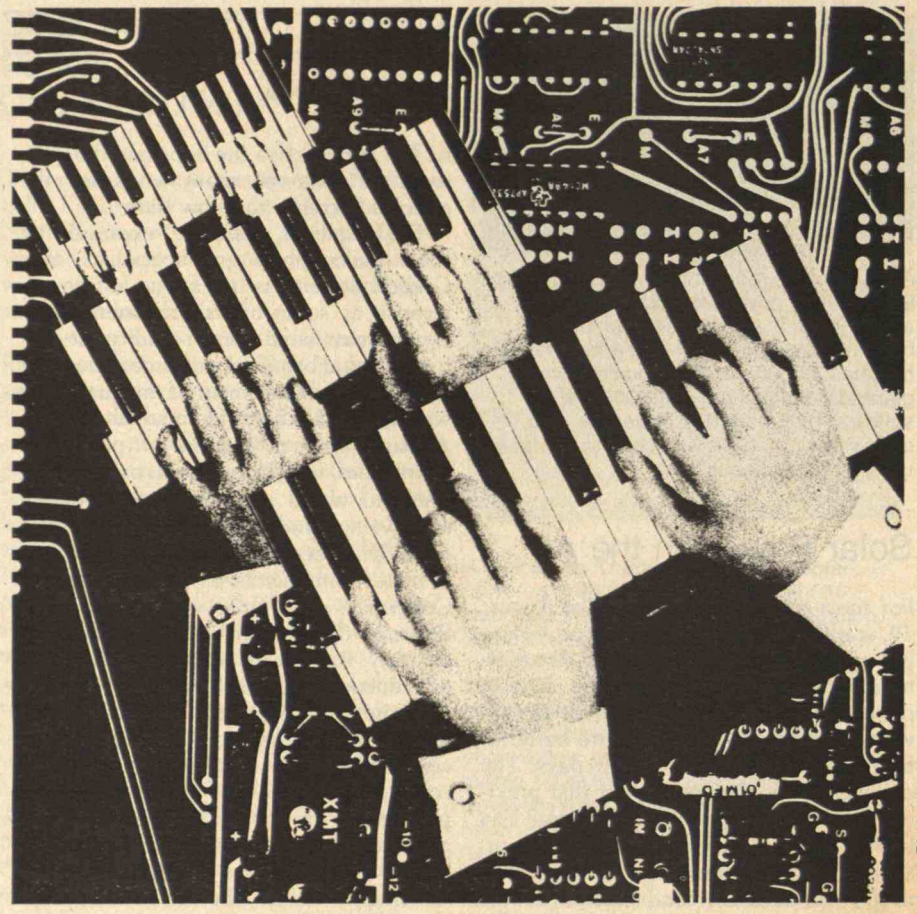
ly. But there is also the hope based on observation that the more we know the easier it becomes to know more.

The suspicion, therefore, expressed by some philosophers and specialists, that General Systems is not as modest an enterprise as some of its proponents proclaim, may have some validity. It can hardly avoid being part of a movement for the general advancement of the quality, as well as the quantity, of human knowledge. As such it is suspicious of premature simplicities, whether religious or scientific. The real world must be more complex than we are, and we are very complex indeed. This does not rule out the discovery of mature simplicities beyond complexity; Copernicus in a sense was simpler than Ptolemy, the periodic table simpler than alchemy. But it leads to a strong suspicion of reductionism, which is premature simplification. It leads also to a search for system hierarchies and for the properties of complex systems that are the result of complexity and cannot be reduced to the properties of simpler components. In addition, it leads to a search for appropriate methodologies in different epistemological fields. The methodology appropriate for celestial mechanics that studies a highly determined equilibrium system may be inappropriate for particle physics and highly inappropriate in the evolutionary sciences.

The search for the unity of human knowledge can itself create pathologies of learning, however, if it is not recognized that in addition to general systems with wide applicability there are also special systems which have unique properties. Of these, the most striking is the human organism itself. We do not know of other examples of systems of this kind, though it seems probable that they exist in a very large universe about which we know very little. Furthermore, each individual human is unique in important respects, certainly in a way that individual hydrogen atoms are not. In systems of this kind, therefore, we have to be wary of generalization. Perhaps we will eventually need a Society for Special Systems Research! In the meantime, in spite of a transition crisis in going from a small group of American scholars to a world organization with a strong sense of mission, one senses a surge of vitality in the Society for General Systems Research which presages an interesting future. □

by Marjorie Lyon

A Third Medium for the Music Composer: Computers



Judith Richland

A painter doesn't take on the whole world. The artist works within limitations — it will be this big, in these colors, with this amount of motion. In the case of a music composer working on a piece, he or she is typically restricted to a limited set of timbres or instruments.

This is especially important when composing computer music, says Barry L. Vercoe, associate professor of music, who founded M.I.T.'s Experimental Music Studio and directs a summer composition workshop. The computer affords the composer a literally limitless choice of sounds, even beyond those of the conventional instruments. Some can be simulated immediately, some only after painstaking research. So time is spent on not just creating musical compositions, but on the construction of specifically desired "instruments."

How is it done? At M.I.T.'s experimental music studio, the composer can use two computers, a PDP–11/50 (a gift to the studio from Digital Equipment Corp. in 1973), and an IMLAC PDS–4.

To make the computer accessible to the composer, Professor Vercoe developed a computer language that gives the composer the luxury of working in his own medium, the musical note. "To the majority of composers, a standard computer-based system is artistically inhibiting," he explains. "Card punches, teletypes, and printers are ill-suited to conveying musical information."

Using Professor Vercoe's system, the composer can type melodies onto a keyboard and see the result on a screen in front of him, displayed in standard music notation. He can create a large, complex score and can make modifications as he goes. Upon request, the computer system will synthesize and play back any segment of that score. And it will print copies of the score and parts for individual players. "The screen is quite intelligent," says Professor Vercoe. "It has the intelligence of about a second-year music student."

Like an Experienced Performer

Professor Vercoe also has additional methods of approaching the computer — "much as a composer would approach an experienced performer, communicating about the control of the performance at a higher level than the details of individual notes, talking about phrase structures and the manner the notes should be communicated and distributed over various octaves. I would then have the computer play it back to me, and I would say 'yes, that's right," or 'no, try again or make a change,' " he explained to David MacNeill in an interview on WCRB radio.

"I went to the console with a sketch of the piece in mind, an indication to the computer of what my technique of putting the piece together should be for this very small segment, and then left the details to the computer. It simply took care of the details and reported back. The thing that I was really honing in this case was not the computer performance, but rather my communication of the control to the machine. If I was incomplete in my communication, the computer performance reflected that, and I had to restate it until it got it straight," he added.

One Instrument at a Time

The computer doesn't compose, it performs the music by drawing sound waves with numbers. The more numbers per second, the better the sound, and some 40,000 numbers per second are typically required for high-fidelity sound for each of four channels if it's quadraphonic. These are then converted to electrical voltages to produce a signal that can be tape-recorded or used to activate a speaker system.

This does not happen quickly. The computer must simulate one instrument at a time and then add them all together. When it does this, a single machine can "play" all of the instruments of an orchestra at the same time.

Standard computers can synthesize only simple sound waves at the speed to be presented to the listener, or in "real time" (sound generated as fast as you hear it). For more interesting, complex sounds, the computer needs to take its time. The synthesis of a complex ensemble using high quality sounds can take the computer 10 or 20 times longer to develop than the sound will actually play in performance.

It builds the sound up slowly, on a digital storage medium such as a disc. (A disc may hold 20 minutes of music in mono,

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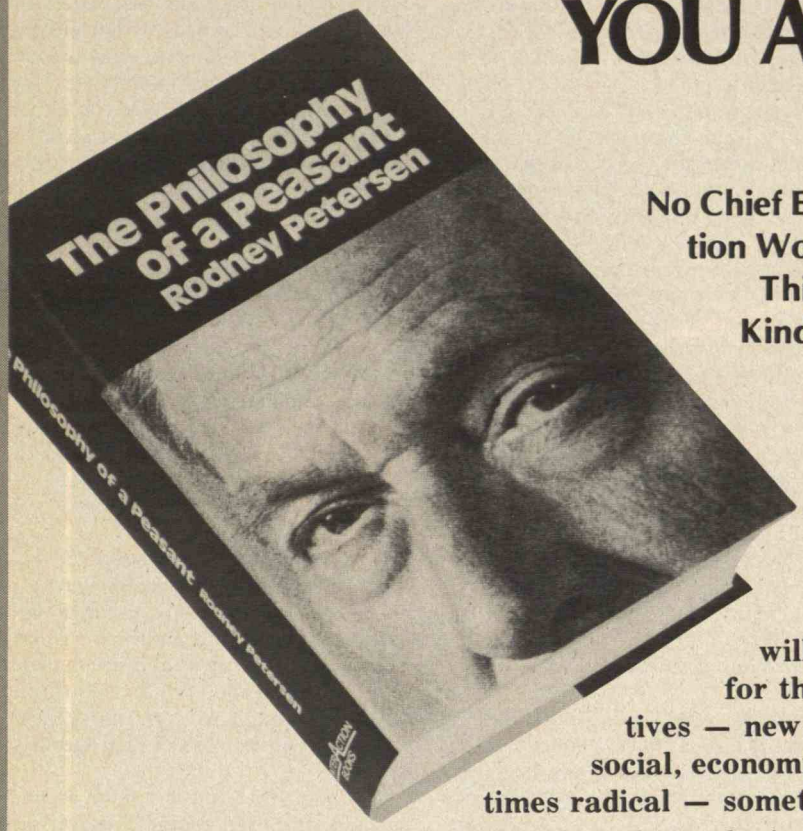

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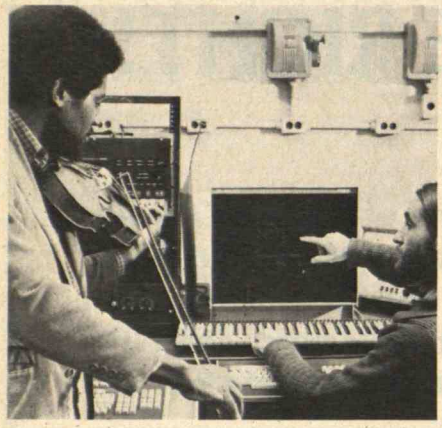


Composer Barry L. Vercoe, associate professor of music (*right*) works with violist Marcus A. Thompson, associate professor of music, on a piece for viola and computer. For the past two summers, Professor Vercoe has shared his insights with students in a workshop for composers. It is in two parts: a two-week program on the techniques of digital sound synthesis (taken by composers, engineers, and people in the audio industry), and then a three- or four-week workshop for composers of considerable experience.

10 minutes in stereo, 5 minutes in quad.) Digitized sound on the disc can be burst back at the correct frequency and converted from digital to analog to permit the hearing of the piece at its correct speed.

Live Performer Input: Vital, and Absent

Music synthesized this way, stored on analog magnetic tape in a standard tape recorder, can be transported to a concert hall and played back for an audience. Herein lies a problem.

"Most composers in our summer workshops have usually had considerable experience in writing for traditional ensembles and traditional instruments. They have come to rely, to a very large extent, on the contribution made by a live performer," Professor Vercoe told David MacNeill. "A musical score written by a composer is basically a framework upon which performers drape an entire communication to the listener," he continued.

So when a composer chooses to express his work through a digital computer, his is a "canned" performance. However painstakingly it was constructed, the music lacks the element of live performance. The composer must take on the responsibility of "adding to his original concept all of those subtle nuances that live performers have traditionally contributed to scores in order to bring the music to life," explains Professor Vercoe. These vital additions to the score are seldom represented in traditional music notation, which affords only a skeleton guide.

A live performer may be used in conjunction with the computer, as a violinist in a violin concerto; the performer plays with the computer as a background and accompaniment. But here, too, the problem is acute. A live performer must synchronize his own performance with a prerecorded performance on electronic tape, which is played at a fixed speed. Thus he or she relinquishes the traditional freedom of tempo in the performance.

There will eventually be a solution, says Professor Vercoe. It will come with the development of very-high-fidelity digital synthesizers that can perform complex compositions in real time. Then there could be an interaction between computer and live performers — "the final emancipation of the medium," he says.

Survival of the Fittest: A Third Medium is Tested

In the 1600s, what had been largely a choral tradition of music changed to instrumental: violins were at the height of their development; chamber orchestra and symphony instruments could produce sounds as interesting as the human voice. The instrument had previously been only an accompaniment to voice. Now it rose to a parallel position, allowing composers two major resources.

Each time an instrument like the violin was invented, it was subjected to years of experiments and tests regarding its ability to produce interesting sounds. "Those instruments that failed the test, or interested only a few people, were those that did not titillate the hearing mechanism at all its various levels of information decoding. Such instruments failed to have a literature written for them and simply fell into disuse.

"This process of 'natural selection' has always gone on in musical instrument making," says Professor Vercoe, and "the development of computer music will be little different from the development of instruments in the past. Natural selection will be rigorously applied to the computer."

What we're seeing now is the active development of a third medium — not of mechanically produced sound (like a violin) but of electronically produced sounds. But these changes don't come about overnight, or in one year, or in one decade. As in the 17th century, they take 50 or so years.

"The thing that has fascinated me," says Professor Vercoe, "is that electronically produced sounds are now achieving an equal ability to be interesting. Not to replace other music but to join it, either as sounds to be heard in the concert hall alone or sounds joined with either or both of the other forces, affording the composer an enriched palette.

"We see an ever-increasing array of synthetic instruments using electronic and digital technology. Those techniques that last will be those that can be refined to the point where they can respond to the composer's need for control of detailed information. The listener will insist on this interest in the sound if he is going to stay at the concert."

"A Labful of Sci-Fi Tinglers"

Where is computer music headed? "To the concert hall," says Professor Vercoe emphatically. He can now manipulate the sound enveloping an audience so that he has control of space as another dimension in music. With speakers located throughout the room, "we can move sounds around the auditorium at high speeds," he explains.

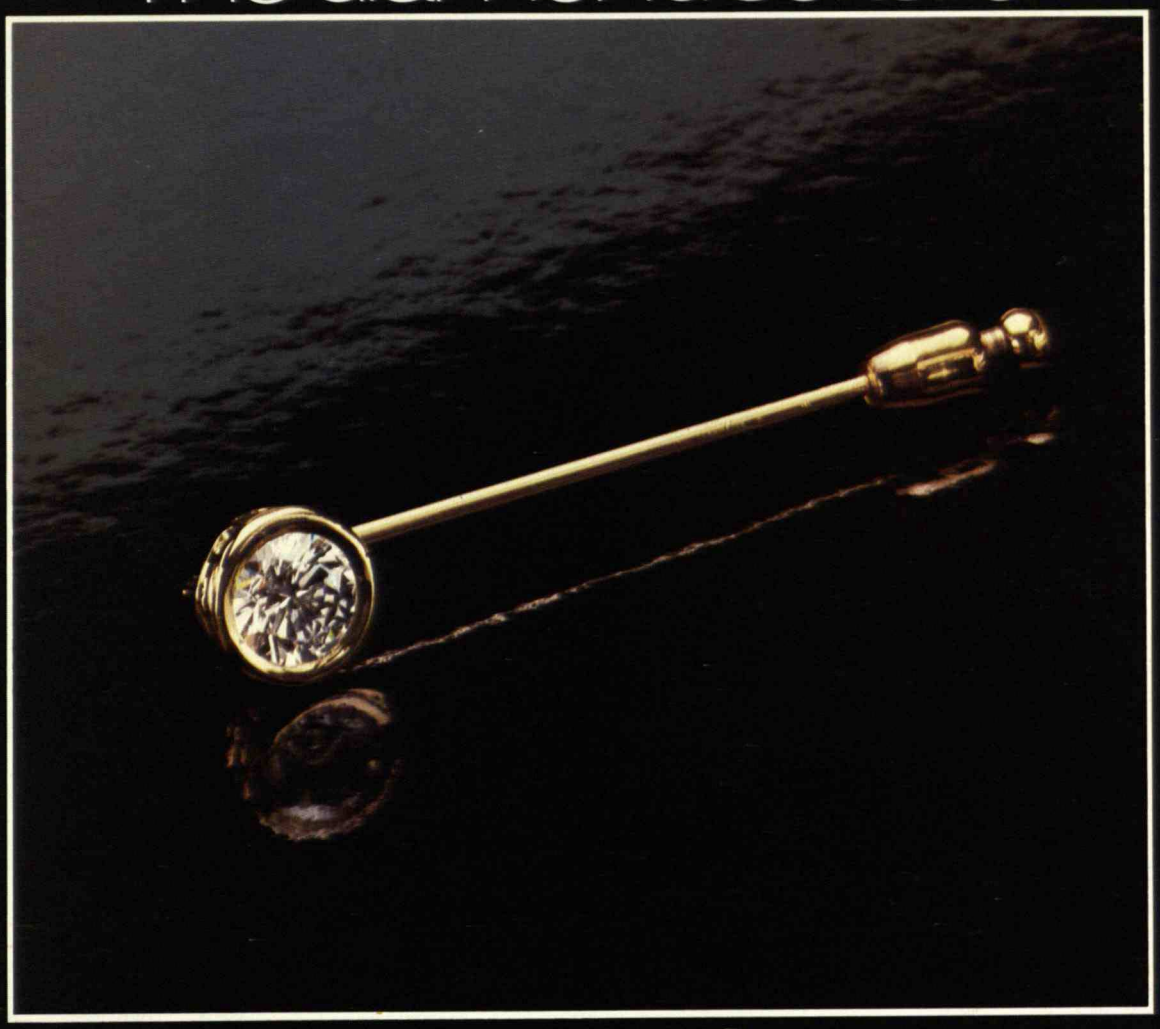
The computer music studio at M.I.T. has put on seven major concerts under Professor Vercoe's direction. "Three years ago concerts were not always accepted as legitimate music. There would likely be walkouts from the first row near the beginning of the concert," he says. It was unrecognizable as music, sniffed a *Boston Globe* reviewer at that time.

This summer, Professor Vercoe's concert in Kresge received quite a different response. "From what one can tell, everyone was extremely interested," he says. The *Globe*'s Richard Buell wrote of one piece by Richard Boulanger: "This had the makings of a sonic spectacular. It trafficked knowingly in extremities of volume and pitch, worked with a colorful palette, and sucessfully evoked a labful of sci-fi tinglers and their ilk."

And a large audience stayed to the finale.

Marjorie Lyon's name first appeared on Technology Review*'s editorial masthead in October, 1974, and almost continuously since then her "beat" has been events at M.I.T.*

The diamond solitaire.



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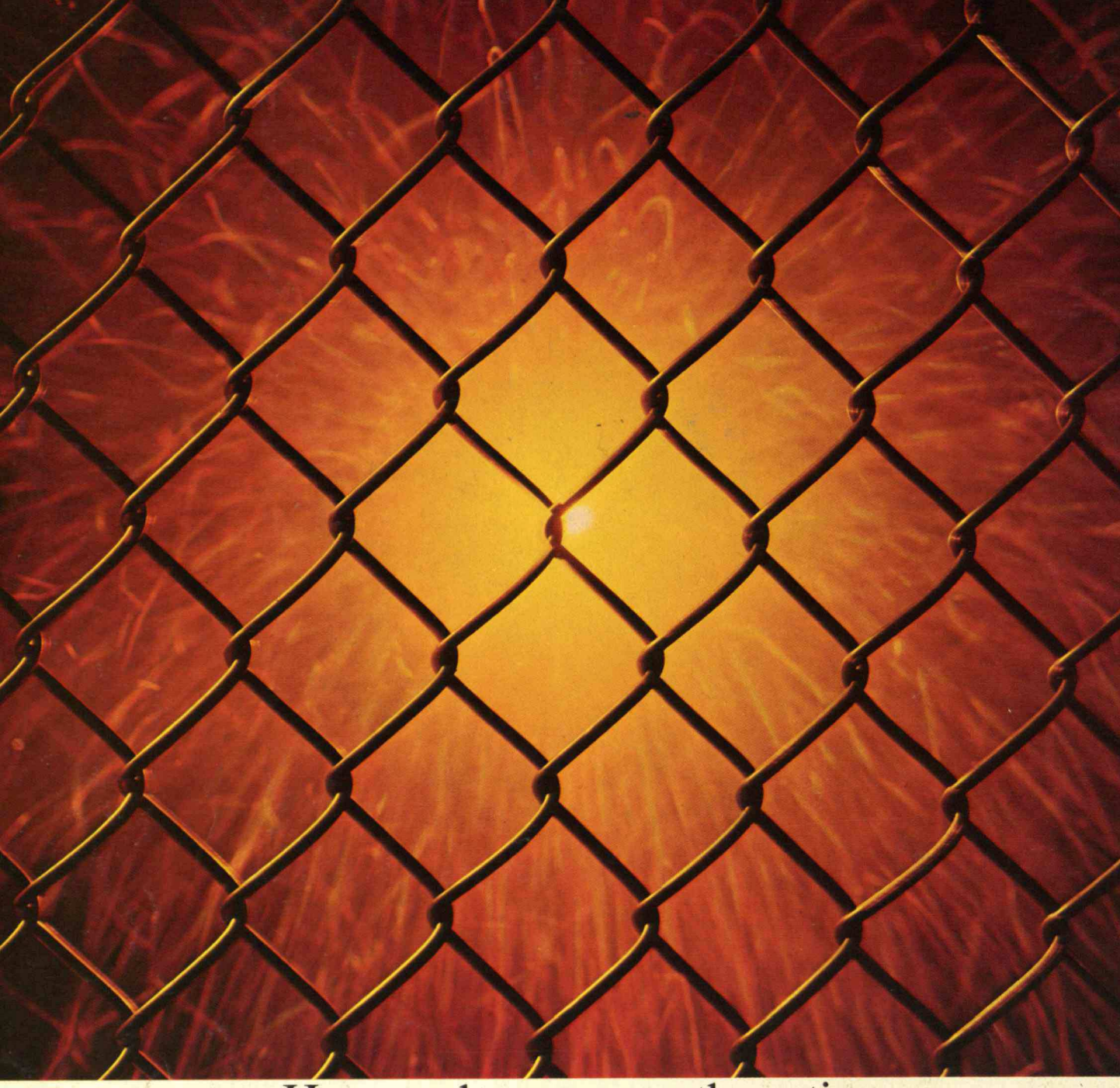

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